ISSN : 2165-4069(Online)
ISSN : 2165-4050(Print)

IJARAI

International Journal of Advanced Research in Artificial Intelligence

Volume 1 Issue 5

www.ijarai.thesai.org

A Publication of
The Science and Information Organization

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH IN ARTIFICIAL INTELLIGENCE

THE SCIENCE AND INFORMATION ORGANIZATION

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Editorial Preface

From the Desk of Managing Editor…

"The question of whether computers can think is like the question of whether submarines can swim." ― Edsger W. Dijkstra, the quote explains the power of Artificial Intelligence in computers with the changing landscape. The renaissance stimulated by the field of Artificial Intelligence is generating multiple formats and channels of creativity and innovation. This journal is a special track on Artificial Intelligence by The Science and Information Organization and aims to be a leading forum for engineers, researchers and practitioners throughout the world.

The journal reports results achieved; proposals for new ways of looking at AI problems and include demonstrations of effectiveness. Papers describing existing technologies or algorithms integrating multiple systems are welcomed. IJARAI also invites papers on real life applications, which should describe the current scenarios, proposed solution, emphasize its novelty, and present an in-depth evaluation of the AI techniques being exploited. IJARAI focusses on quality and relevance in its publications. In addition, IJARAI recognizes the importance of international influences on Artificial Intelligence and seeks international input in all aspects of the journal, including content, authorship of papers, readership, paper reviewers, and Editorial Board membership.

In this issue we have contributions on genetic algorithm approach for scheduling of resources in well-services companies; improvement direction for filter selection techniques using information theory measures and quadratic optimization; comparative study on different ai techniques towards performance evaluation in RRM(Radar Resource Management); integrated information system of monitoring and management for heart centers; an alternative design approach to an intelligent change over system based on fuzzy logic controller for domestic load management; and also a Introduction of the weight edition errors in the Levenshtein distance.

The success of authors and the journal is interdependent. While the Journal is in its initial phase, it is not only the Editor whose work is crucial to producing the journal. The editorial board members , the peer reviewers, scholars around the world who assess submissions, students, and institutions who generously give their expertise in factors small and large— their constant encouragement has helped a lot in the progress of the journal and shall help in future to earn credibility amongst all the reader members. I add a personal thanks to the whole team that has catalysed so much, and I wish everyone who has been connected with the Journal the very best for the future.

Thank you for Sharing Wisdom!

Managing Editor
IJARAI
Volume 1 Issue 5 August 2012
ISSN: 2165-4069(Online)
ISSN: 2165-4050(Print)

Editorial Board

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A genetic algorithm approach for scheduling of resources in well-services companies

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***Abstract*— In this paper, two examples of resources scheduling in well-services companies are solved by means of genetic algorithms: resources for call solving, people scheduling. The results demonstrate that the genetic algorithm approach can provide acceptable solutions to this type of call solving for scheduling in well-services companies. The suggested approach could be easily extended to various resource scheduling areas: process scheduling, transportation scheduling.**

Keywords- Genetic algorithm; optimization; well-services.

I. Introduction

The resource scheduling problem has wide application. Resources could be people, equipments, devices, rooms, cars etc. The scheduling of resources is often encountered in industrial organizations, shopping centers, call centers, hospitals etc [1-4, 6, 8, 10]. Various approaches are popular in solving the resource scheduling problem: linear programming, backtracking, branch-and-bound, etc. Due to their flexibility, we have chosen to provide solution using genetic algorithms.

The scheduling of incidental and regular maintenance operations in well-services companies is an important topic due of its direct connection with production stopping and financial implications. Also, the companies providing well services are working into a competitive environment and they need to efficiently and quickly compute the schedules for well interventions. Additionally, the costs for well fixing may be computed based on well location, type of call etc [9]. In this context, an efficient algorithm for schedule generation is needed. The provided algorithm should be able to deal with re-scheduling problems.

II. Resource Allocation for Call Solving

A. Problem formulation

In well-services companies, the concept of calls is used to manage the issues or regular maintenance requests for wells. Mainly, there are two kinds of calls: incident calls arisen from a malfunction or incident at a well, with high priority, and regular calls for periodical maintenance operations, low priority. Some of typical well interventions are: pumping, wellhead and "Christmas tree" maintenance, slick line, braided line, coiled tubing, snubbing, workover. For such well interventions, there is need to schedule appropriate resources, depending on their skills.

Each call could be defined by four characteristics:

- type of call, needed resources (number and skill) for solving it
- location of the well where the call occurred
- duration for completion

The target is to optimally allocate resources to be able to solve all calls before their dead-line. A similar approach for real-time scheduling of resources was found in [6].

TABLE I. Example of a Database Storing Calls

Call Identifier	Skill1	Skill2	Skill3	Location	Duration	Dead-line
201	0	1	0	Loc2	1	10
202	0	1	0	Loc2	1	10
203	0	1	0	Loc2	1	10
901	0	1	0	Loc2	1	11
902	0	1	0	Loc2	1	11
903	0	1	0	Loc2	1	11
301	0	0	1	Loc3	2	12
101	1	0	0	Loc1	2	14
102	1	0	0	Loc1	2	14
103	1	0	0	Loc1	2	14
801	1	0	0	Loc1	2	15
802	1	0	0	Loc1	2	15
803	1	0	0	Loc1	2	15
601	0	1	0	Loc2	4	16
701	1	0	0	Loc1	5	16
401	0	1	0	Loc1	3	17
501	0	0	1	Loc3	3	17

Table 1 contains an example of database with details for calls: needed skills, location, duration and target dead-line. For each skill, a flag with 0 or 1 value is used. The number of skills taken into account skills can be easily extended. The Location column is presenting the place were the call should be fixed. Duration is the needed time to fix the call. Deadline is the time limit until when the call should be closed. All calls are ordered by deadline.

The proposed model of input data, based on ordering by dead-line of calls, is allowing re-scheduling of the existing items from data-base every time when new entries appear. Only not yet started calls (including transportation) are re-scheduled.

TABLE II. Example of a Database with Resources

Identifier	Skill1	Skill2	Skill3	Location
Resource1	1	0	0	Loc0

Resource2	0	1	0	Loc0
Resource3	1	0	0	Loc0
Resource4	0	1	0	Loc0
Resource5	0	0	1	Loc0

An example of database with resources is included in table 2. Each resource has an identifier. The skills of the resources are encoded using flags for each skill, in a similar way with the calls. The location of each resource is different than the location of calls and all resources are grouped together in the well services operation center.

Similar approaches to encode problems can be derived for process scheduling in manufactories or for transportation scheduling.

B. Problem solution

Figure 1 contains the sketch of the used approach for resource scheduling.

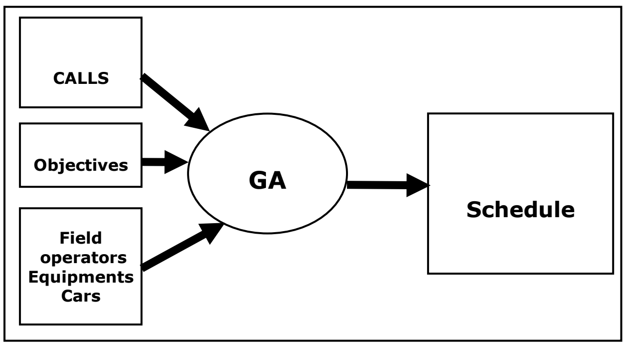

Figure 1. The genetic algorithm mixes all inputs and generates the schedule

The requests formulated by calls are fulfilled by scheduling of resources (field operators, equipments, cars). This schedule is generated by genetic algorithm that is using special objectives. Such kind of objectives could be: schedule all tasks before their deadline, the time for fulfilling the last task should be as early as possible.

1) Chromosome encoding

The GA chromosomes are arrays containing the identifiers of resources which will solve each call from database. The resource located at position k will solve the call no k.

TABLE III. CHROMOSOME ENCODING AND ALLOWED RANGES FOR EACH ELEMENT

	Call ID#1	Call ID#2	…	Call ID#n
Min value (not scheduled resources)	0	0		0
Max value (the maximum value of resource identifier)	5	5		5

In table 3, the used encoding from chromosomes is presented. For each call, a gene will have a value from 0 to the maximum value of the resource identifier. Because all resources are consecutively numbered, the maximum value for resource identifiers is the total number of existing resources. The special value 0 is used for not scheduled resources. This approach is allowing the genetic algorithm not to schedule any resources for the low priority calls, in case of huge number of existing calls in database.

This type of representation can completely encode a schedule for all calls from database.

2) Objective function

The database with calls is always ordered by deadline. The objective function is evaluating the completion time of each call as it is encoded by chromosomes, as it follows: b) a call is started as soon as possible when all scheduled resources are free; b) the finishing time is the starting time to which it is added the necessary time for completion.

A penalty factor is computed for not scheduled calls and for missed deadlines.

The used objective function is a measure of the total delay, namely the sum of differences between completion time and due date for each call [7]:

$$L = \sum_{i=1}^{n} c_i - d_i$$

where L is the total latency, c_i is the completion time of call i, d_i is the deadline of call i, n is the total number of calls, i is an index between 1 and n.

Minimizing the total delay is a MIN-SUM problem [7].

Another used objective function is designed to minimize the time of completion of the last task, also known as makespan [7].

The corresponding equation for the makespan optimization is:

$$C = \max\left(c_1, c_2, \text{K}, c_n\right)$$

where C is the maximum, c_1,c_1,...,c_n are the completion times of calls 1...n.

The makespan is also used to measure the utilization time of the resources. The makespan minimization is a MIN-MAX problem [7].

3) Constraint setting

For each gene, the minimum and maximum values are set: minimum value is 0, maximum values is the number of field operators. The value 0 is used for not scheduled resources. These limit values are grouped in a 2-rows constraint matrix with a number of columns equal to the chromosome's length. Using this constraint matrix, all constraints are specified and they will be checked to be fulfilled during the generation of the initial population after the application of the mutation operator.

4) Initial population

An initial population is generated using a default functionality of the "MATLAB Genetic Algorithms and Direct Search" toolbox [5]. The generated population satisfies the minimum and maximum values from the constraint matrix. A value of 200 was used for the GA population size.

5) Genetic operators

Elitism: The elitism operator is set to select 1 individual (the best one) for the next generation.

Mutation: A customized algorithm was implemented for the mutation operator. This modifies the values of the genes with a random value that preserves the allowed range; mutated genes were kept between the allowed minimum and maximum. The fraction for mutation was set to approx 0.01.

Cross-over: The customized crossover operator is a single point crossover algorithm. By itself, this operator preserves the range of the allowed values for genes. The crossover fraction was set at 0.6.

6) Other genetic algorithm settings

It was used for the tournament selection with rank based scaling of the fitness. The maximum number of generations was 100.

III. RESULTS

The genetic algorithm is iterating and its final best individual is representing the solution of the formulated problem.

The first defined problem is to schedule all resources so that all calls must be solved before their deadline. The table 4 and figure 2 are presenting the obtained results.

The Gantt chart from figure 2 is showing how each resource is allocated to solve various calls. In case of the resource number 2, the first set of solved calls is located at a different location than the call 401; thus, there is need for an extra time to travel from location number 2 to location number 1.

Table 4 presents an example of obtained schedule. The resulted schedule is allowing the scheduling needed resources to fulfill all calls, prior to their deadline. By comparing the Time and Target Time columns, it can be observed that all calls are solved at least until the time of the dead-line.

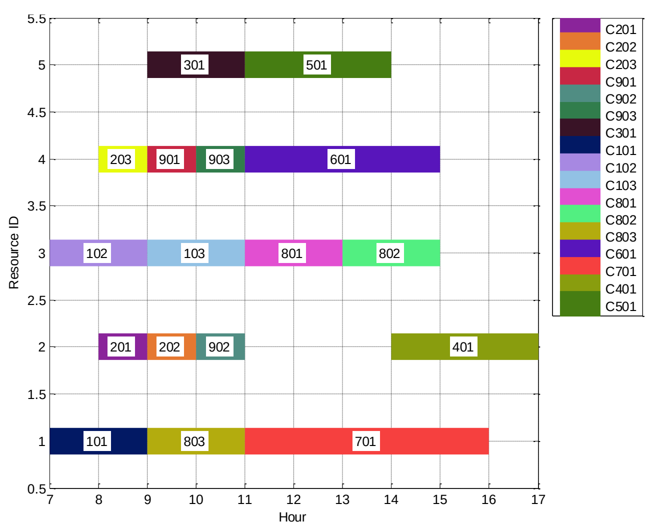

Figure 2. The Gantt chart of the generated schedule for the solving prior deadline problem. The Y axis is showing the value of resource identifier. Starting and finishing time is expressed in hours, on X axis. The ID of calls is visible in corresponding rectangle and also on legend.

TABLE IV. THE SCHEDULE GENERATED BY GENETIC ALGORITHM FOR THE SOLVING PRIOR DEADLINE PROBLEM

Call ID	Resource ID	Time	Target Time	Duration	Location (time to cover distance)
201	2	9	10	1	2
202	2	10	10	1	2
203	4	9	10	1	2
901	4	10	11	1	2
902	2	11	11	1	2
903	4	11	11	1	2
301	5	11	12	2	3
101	1	9	14	2	1
102	3	9	14	2	1
103	3	11	14	2	1
801	3	13	15	2	1
802	3	15	15	2	1
803	1	11	15	2	1
601	4	15	16	4	2
701	1	16	16	5	1
401	2	17	17	3	1
501	5	14	17	3	3

The second defined problem is to schedule all resources such that the time needed to fulfill all requests (makespan) is minimum. The obtained results are presented in table 5 and figure 3.

TABLE V. THE SCHEDULE GENERATED BY GENETIC ALGORITHM FOR THE MAKESPAN MINIMIZATION PROBLEM

Call ID	Resource ID	Time	Target Time	Duration	Location (time to cover distance)
201	2	9	10	1	2
202	2	10	10	1	2
203	2	11	10	1	2
901	4	9	11	1	2
902	4	10	11	1	2
903	2	12	11	1	2
301	5	11	12	2	3
101	3	9	14	2	1
102	1	9	14	2	1
103	3	11	14	2	1
801	3	13	15	2	1
802	3	15	15	2	1
803	1	11	15	2	1
601	2	16	16	4	2
701	1	16	16	5	1
401	4	16	17	3	1
501	5	14	17	3	3

For the call 903, there is a delay of 1 hour between target time and completion time.

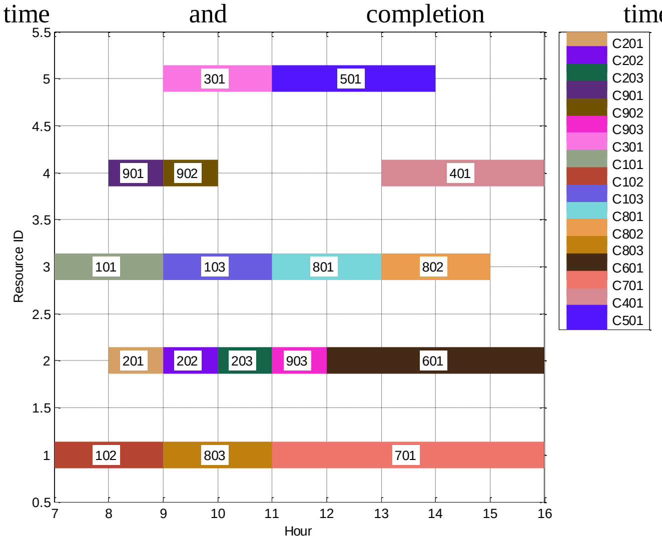

Figure 3. The Gantt chart of the generated schedule for the makespan minimization problem. The Y axis is showing the value of resource identifier. Starting and finishing time is expressed in hours, on X axis. The ID of calls is visible in corresponding rectangle and also on legend.

In case of makespan minimization, the completion time for the last call is 16. But the 1st dead-line is missed. As a note: the attempt to combine both goals (solving prior dead-line and make span minimization) on this configuration of database was leading to the same results as in the first approach, a value of 17 for the last completion time with all deadlines fulfilled.

IV. Staff Scheduling for Well Services Companies

A. Problem description

In case of well-services companies, an example of a team is composed as follows: workers, technical coordinator, team leader. Due to their roles they have different type of shifts: 12 hours day / night shifts for workers, 8 hours day shifts for the technical coordinator and team leader. The schedule for workers is organized in a 28 days pattern, as in table bellow. This alternate of day shifts (noted with D), night shifts (N), and free days (-) is assuring a proper fulfillment of rules concerning rest time and the total amount of needed work hours during a month.

TABLE VI. The Pattern for Workers

DAY																											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-	D	D	D	N	N	-	-	-	-	-

The team leaders and technical coordinators are scheduled using a pattern with 8 hours day shift (named Flex), only from Monday to Friday.

Additional types of events are: time off, preference day off, preferably working day.

TABLE VII. The Pattern for Team Leaders and Technical Coordinators

DAY						
Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
F	F	F	F	F	-	-

The genetic algorithm should generate an automated planning, for each team separately for at least 4 employees for a period up to 6 months.

In this planning, the system must take into account the following rules in the order described below:

1. For each team, there should be no interval uncovered with shifts found with type D and N

2. Allocation pattern with D and N shifts for workers is respecting the table 6.

3. Flex allocation pattern shifts for team leader and technical coordinator is exactly as in table 7.

4. The allocation system for D and N shifts will take into account of the events included in the calendar such as Time Off, preferably day off and preferably working day. When the system will meet one of the special calendar events, the system will schedule the event and then the current pattern will be reset.

5. If there are situations when some time intervals remain uncovered with workers, the team coordinator can take tours of type D or N

6. If the team has more than 4 workers, and the above conditions are met, after a complete rotation of 28 days, their schedule will continue with Flex week, and then it will return to pattern.

7. The coordinators will have Flex shifts, as default, except point 5.

8. Team leaders will have only Flex shifts.

B. Problem solution

1) Chromosome encoding

The basic idea of data representation for this problem is to circular shift the schedule pattern with various numbers of positions for each employee.

The chromosomes are containing numbers indicating the number of positions to shift.

In case of teams with more than 4 workers, the regular pattern is extended with a week Flex pattern. In this case, the pattern is 35 days long. The usage of multiple of 7 numbers for values in chromosomes was leading to good enough results of the generated schedules. Additionally, such weekly shiftings were produced more human readable schedules compared with the approach of daily shifting of patterns. Depending of the length of the pattern, the range of shiftings is from 0 to 3 (for 28 days pattern) and form 0 to 4 (for 35 days pattern).

In case of the team leader, no shifting is needed due to request to allow only Flex schedule pattern. In case technical coordinator, the pattern could be a mix of worker's pattern and

Flex pattern. So, the maximum number of shiftings for technical coordinator is either 0 or 3 or 4.

TABLE VIII. CHROMOSOME ENCODING AND ALLOWED RANGES FOR EACH ELEMENT

	Worker 1	…	Worker n	Technical Coordinator	Team Leader
Min	0		0	0	0
Max	maxShifts {3 or 4}		maxShifts {3 or 4}	maxTCShifts {0, 3 or 4}	0

In table 8, the encoding of chromosomes and allowed ranges for each gene is presented. The allowed range is differing according to employee's role.

This kind of representation can completely encode the schedules of all employees.

2) Objective function

The objective function is deriving a schedule starting from chromosome encoded shifting positions. The vectors encoding the used patterns are shifted using the values stored inside chromosomes. A temporary schedule is computed first. Then, the schedule is processed by applying special events as preferable day off, or time off or preferable working day. Another step is the update of schedule by resetting pattern after each special calendar event. Next step is the enhancement of schedule by forcing the technical coordinator to cover the missed Day or Nights shifts, if it is the case. Last step is the evaluation of the final schedule: the still missed Day or Night shifts are highly penalized (100 * no_of_missed_shifts); the difference between number of covered Day and Night shifts targeted to be as close as possible to 0.

The equation of objective function is:

$$F = 100 * no\_of\_missed\_shifts + abs(no\_of\_day\_shifts - no\_of\_night\_shifts)$$

The goal of the used genetic algorithm is to minimize the value of F.

Even the algorithm of population generating or the used mutation or cross-over algorithms are producing floating point values for genes, the objective function is using rounded values for content of chromosomes.

3) Constraint setting

The minimum and maximum values are set, for each gene: minimum value is 0, maximum values are represented by the number of allowed shiftings. These limits are preserved during evolving of the genetic population. The limit values are included into a constraint matrix.

4) Initial population

The initial population is generated using a modified shape of the uniform method from "MATLAB Genetic Algorithms and Direct Search" toolbox [5]. This method is preserving the minimum and maximum values from the constraint matrix. The GA population size was set to 100 individuals.

5) Genetic operators

Elitism: The number of elitist individual which are automated selected into next generation was 1.

Mutation: A modified shape of the uniform mutation was used as mutation operator. The used operator is checking the preserving of linear constraints. The default fraction for mutation was used.

Cross-over: The used crossover operator is a multipoint crossover version from GADS toolbox [5]. This crossover operator preserves the range of the allowed values for genes. The crossover fraction was set at 0.6.

6) Other genetic algorithm settings

The tournament selection with rank based scaling of the fitness was used. The maximum number of generations was 50.

C. Results

First set of results is for a team with 11 workers and 1 Team Leader / Technical coordinator.

In this case, there were special events, of type preferably day off for the team leader person and for the worker 10. The special events are gray-highlighted in table 9.

TABLE IX. RESULTED SCHEDULE FOR A TEAM WITH 11 WORKERS AND 1 TEAM LEADER / TECHNICAL COORDINATOR

	November, 2010																														December, 2010				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5
Worker 1	D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-	D	D	D	N	N	-	-	-	-	-	F	F	F	F	F	-	-
Worker 2	-	-	-	-	D	D	D	N	N	-	-	-	-	-	F	F	F	F	F	-	-	D	D	N	N	-	-	-	-	-	D	D	N	N	N
Worker 3	N	N	-	-	-	-	-	F	F	F	F	F	-	-	D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-	D	D	D
Worker 4	F	F	F	F	F	-	-	D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-	D	D	D	N	N	-	-	-	-	-
Worker 5	-	-	D	D	N	N	N	-	-	-	-	D	D	D	N	N	-	-	-	-	-	F	F	F	F	F	-	-	D	D	N	N	-	-	-
Worker 6	F	F	F	F	F	-	-	D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-	D	D	D	N	N	-	-	-	-	-
Worker 7	D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-	D	D	D	N	N	-	-	-	-	-	F	F	F	F	F	-	-
Worker 8	-	-	-	-	D	D	D	N	N	-	-	-	-	-	F	F	F	F	F	-	-	D	D	N	N	-	-	-	-	-	D	D	N	N	N
TC /TL	-	F	F	F	F	-	-	F	F	F	F	F	-	-	F	F	F	F	F	-	-	F	F	F	F	F	-	-	F	F	F	F	F	-	-
Worker 9	-	-	D	D	N	N	N	-	-	-	-	D	D	D	N	N	-	-	-	-	-	F	F	F	F	F	-	-	D	D	N	N	-	-	-
Worker 10	N	N	-	-	-	-	-	F	F	F	F	F	-	-	-	-	-	D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-
Worker 11	N	N	-	-	-	-	-	F	F	F	F	F	-	-	D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-	D	D	D

TABLE X. RESULTED SCHEDULE FOR A TEAM WITH 3 WORKERS, 1 TECHNICAL COORDINATOR AND 1 TEAM LEADER

	November, 2010																														**December, 2010**				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5
Worker 1	D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-	D	D	D	N	N	-	-	-	-	-	D	D	N	N	-	-	-
Worker 2	N	N	-	-	-	-	-	D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-	D	D	D	N	N	-	-	-	-	-
Worker 3	-	-	-	-	D	D	D	N	N	-	-	-	-	-	D	D	N	N	-	-	-	-	-	D	D	N	N	N	-	-	-	-	D	D	D
T. C.	-	-	D	D	N	N	N	-	-	-	-	D	D	D	N	N	-	-	-	-	-	D	D	N	N	-	-	-	-	-	D	D	N	N	N
T. L.	F	F	F	F	F	-	-	F	F	F	F	F	-	-	F	F	F	F	F	-	-	F	F	F	F	F	-	-	F	F	F	F	F	-	-

All rules were fulfilled, including the special events. Additionally, the algorithm was tacking care to balance for each the number of people scheduled for Day or Night shifts, to avoid situations with all except one people scheduled for the night shift.

Another example is presented in table 10. Here, the team is consisting in 3 workers, 1 technical coordinator and 1 Team Leader. For this configuration of team, the technical coordinator is following exactly the pattern or regular workers.

The used pattern is only 28 days long. For the last days of the current month, the pattern is repeated – as it can be seen in the gray-highlighted portion of table 10.

In this configuration, all requirements are fulfilled. The difference between total number of day shifts and total number of night shifts is 0.

V. Conclusion

Two problems for resource scheduling in case of well services companies were presented in this paper: resource allocation to solve calls and people scheduling for working. For the solving of calls problem, there were proposed two methods: solving before deadline and makespan minimization. Both approacheds had accurate results. Additionally, the proposed approaches are allowing re-scheduling of resources for calls.

The proposed solution for the shift based people scheduling for working has accurate results. Our solution is tacking care of special events too.

In conclusion, the results appear to show that this resource scheduling problem has an acceptable solution via the genetic algorithm approach.

In the future, we intend to extending to process for scheduling or for transportation scheduling. As further extensions, some indicators of resources usage or resource availability could be derived.

Acknowledgment

This work has been supported by the Greensoft Ltd. company, Romania.

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An improvement direction for filter selection techniques using information theory measures and quadratic optimization

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Abstract— **Filter selection techniques are known for their simplicity and efficiency. However this kind of methods doesn't take into consideration the features inter-redundancy. Consequently the un-removed redundant features remain in the final classification model, giving lower generalization performance. In this paper we propose to use a mathematical optimization method that reduces inter-features redundancy and maximize relevance between each feature and the target variable.**

Keywords-Feature selection; mRMR; Quadratic mutual information ; filter.

I. Introduction

In many classification problems we deal with huge datasets, which likely contain not only many observations, but also a large number of variables. Some variables may be redundant or irrelevant to the classification task. As far as the number of variables increase, the dimensions of data amplify, yielding worse classification performance. In fact with so many irrelevant and redundant features, most classification algorithms suffer from extensive computation time, possible decrease in model accuracy and increase of overfitting risks [17, 12]. As a result, it is necessary to perform dimensionality reduction on the original data by removing those irrelevant features.

Two famous special forms of dimensionality reduction exist. The first one is feature extraction, in this category the input data is transformed into a reduced representation set of features, so new attributes are generated from the initial ones. The Second category is feature selection. In this category a subset of the existing features without a transformation is selected for classification task. Generally feature selection is chosen over feature extraction because it conserves all information about the importance of each single feature while in feature extraction the obtained variables are, usually, not interpretable. In this case it is obvious that we will study the feature selection but choosing the most effective feature selection method is not an easy task.

Many empirical studies show that manipulating few variables leads certainly to have reliable and better understandable models without irrelevant, redundant and noisy data [21, 20]. Feature selection algorithms can be roughly categorized into the following three types, each with different evaluation criteria [7]: filter model, wrapper model and embedded. According to [18, 3, 9] a filter method is a pre-selection process in which a subset of features is firstly selected independently of the later applied classifier. Wrapper method on the other hand, uses search techniques to rank the discriminative power of all of the possible feature subsets and evaluate each subsets based on classification accuracy [16], using the classifier that was incorporated in the feature selection process [15, 14]. The wrapper model generally performs well, but has high computational cost. Embedded method [20] incorporates the feature selection process in the classifier objective function or algorithm. As result the embedded approach is considered as the natural ability of a classification algorithm; which means that the feature selection take place naturally as a part of classification algorithm. Since the embedded approach is algorithm-specific, it is not an adequate one for our requirement.

Wrappers on other hand have many merits that lie in the interaction between the feature selection and the classifier. Furthermore, in this method, the bias of both feature selection algorithm and learning algorithm are equal as the later is used to assess the goodness of the subset considered. However, the main drawback of these methods is the computational weight. In fact, as the number of features grows, the number of subsets to be evaluated grows exponentially. So, the learning algorithm needs to be called too many times. Therefore, performing a wrapper method becomes very expensive computationally.

According to [2, 17] filter methods are often preferable to other selection methods because of their usability with alternative classifiers and their simplicity. Although filter algorithms often score variables separately from each other without considering the inter-feature redundancy, as result they do not always achieve the goal of finding combinations of variables that give the best classification performance [13].Therefore, one common step up for filter methods is to consider dependencies and relevance among variables. mRMR [8] (Minimal-Redundancy-Maximum-Relevance) is an effective approach based on studying the mutual information among features and the target variable; and taking into account the inter-features dependency [19]. This approach selects those features that have highest relevance to the target class with the minimum inter-features redundancy. The mRMR algorithm, selects features greedily.

The new approach proposed in this paper aims to show how using mathematical methods improves current results. We use quadratic programming [1] in this paper, the studied objective function represents inter-features redundancy through quadratic term and the relationship between each feature and the class label is represented through linear term. This work has the following sections: in section 2 we review studies related to filter methods; and we study the mRMR feature selection approach. In section 3 we propose an advanced approach using mathematical programming and mRMR algorithm background. In section 4 we introduce the used similarity measure. Section 5 is dedicated to empirical results.

II. Filter Methods

The processing, of filter methods at most cases can be described as it follows: At first, we must evaluate the features relevance by looking at the intrinsic properties of the data. Then, we compute relevance score for each attribute and we remove ones which have low scores. Finally, the set of kept features forms the input of the classification algorithm. In spite of the numerous advantages of filters, scoring variables separately from each other is a serious limit for this kind of techniques. In fact when variables are scored individually they do not always achieve the object of finding the perfect features combination that lead to the optimal classification performance [13].

Filter methods fail in considering the inter-feature redundancy. In general, filter methods select the top-ranked features. So far, the number of retained features is set by users using experiments. The limit of this ranking approach is that the features could be correlated among themselves. Many studies showed that combining a highly ranked feature for the classification task with another highly ranked feature for the same task often does not give a great feature set for classification. The raison behind this limit is redundancy in the selected feature set; redundancy is caused by the high correlation between features.

The main issue with redundancy is that with many redundant features the final result will not be easy to interpret by business managers because of the complex representation of the target variable characteristics. With numerous mutually highly correlated features the true representative features will be consequently much fewer. According to [8], because features are selected according to their discriminative powers, they do not fully represent the original space covered by the entire dataset. The feature set may correspond to several dominant characteristics of the target variable, but these could still be fine regions of the relevant space which may cause a lack in generalization ability of the feature set.

A. mRMR Algorithm

A step up for filter methods is to consider dissimilarity among features in order to minimize feature redundancy. The set of selected features should be maximally different from each other. Let S denote the subset of features that we are looking for. The minimum redundancy condition is

$$MinP_1, P_1 = \frac{1}{|S|^2} \sum_{x_i, x_j \in S} M(x_i, x_j), \tag{1}$$

where we use *M(i, j)* to represent similarity between features, and |S |is the number of features in S. In general, minimizing only redundancy is not enough sufficient to have a great performance, so the minimum redundancy criteria should be supplemented by maximizing relevance between the target variable and others explicative variables. To measure the level of discriminant powers of features when they are differentially expressed for different target classes, again a similarity measure $M(y, x_i)$ is used, between targeted classes y={0,1} and the feature expression x_i . This mesure quantifies the relevance of x_i for the classification task. Thus the maximum relevance condition is to maximize the total relevance of all features in S:

$$MaxP_2, P_2 = \frac{1}{|S|^2} \sum_{x_i \in S} M(y, x_i). \tag{2}$$

Combining criteria such as: maximal relevance with the target variable and minimum redundancy between features is called the minimum redundancy-maximum relevance (mRMR) approach. The mRMR feature set is obtained by optimizing the problems P_1 and P_2 receptively in Eq. (1) and Eq. (2) simultaneously. Optimization of both conditions requires combining them into a single criterion function

$$Min\{P_1 - P_2\}. \tag{3}$$

mRMR approach is advantageous of other filter techniques. In fact with this approach we can get a more representative feature set of the target variable which increases the generalization capacity of the chosen feature set. Consistently, mRMR approach gives a smaller feature set which effectively cover the same space as a larger conventional feature set does. mRMR criterion is also another version of MaxDep [19] that chooses a subset of features with both minimum redundancy and maximum relevance.

In spite of the numerous advantages of mRMR approach; given the prohibitive cost of considering all possible subsets of features, the mRMR algorithm selects features greedily, minimizing their redundancy with features chosen in previous steps and maximizing their relevance to the class. A greedy algorithm is an algorithm that follows the problem solving heuristic of making the locally optimal choice at each stage with the hope of finding a global optimum; the problem with this kind of algorithms is that in some cases, a greedy strategy do not always produce an optimal solution, but nonetheless a greedy heuristic may yield locally optimal solutions that approximate a global optimal solution.. On the other hand, this approach treats the two conditions equally important. Although, depending on the learning problem, the two conditions can have different relative purposes in the objective function, so a coefficient balancing the MaxDep and the MinRev criteria should be added to mRMR objective function. To improve the theory of mRMR approach we use in the next section; mathematical knowledge to modify and balance the mRMR objective function and solve it with quadratic programming.

III. QUADRATIC PROGRAMMING FOR FEATURE SELECTION

A. Problem Statement

The problem of feature selection was addressed by statistics machine learning as well as by other mathematical formulation. Mathematical programming based approaches have been proven to be excellent in terms of classification accuracy for a wide range of applications [5, 6]. The used mathematical method is a new quadratic programming formulation. Quadratic optimization process, use an objective function with quadratic and linear terms. Here, the quadratic term presents the similarity among each pair of variables, whereas the linear term captures the correlation of each feature and the target variable.

Assume the classifier learning problem involves N training samples and m variables [20]. A quadratic programming problem aims to minimize a multivariate quadratic function subject to linear constraints as follows:

$$Min f(\mathbf{x}) = \frac{1}{2}\mathbf{x}^T Q\mathbf{x} - F^T\mathbf{x}.$$
$$Subjectto$$
$$\begin{cases} x_i \geq 0 \forall i = 1,\ldots, m \\ \sum_{i=1}^{m} x_i = 1. \end{cases} \quad (4)$$

where F is an m-dimensional row vector with non-negative entries, describing the coefficients of the linear terms in the objective function. F measures how correlated each feature is with the target class (relevance). Q is an *(m x m)* symmetric positive semi-definite matrix describing the coefficients of the quadratic terms, and represents the similarity among variables (redundancy). The weight of each feature decision variables are denoted by the m-dimensional column vector $\mathbf{x}$.

We assume that a feasible solution exists and that the constraint region is bounded. When the objective function $f(\mathbf{x})$ is strictly convex for all feasible points the problem has a unique local minimum which is also the global minimum. The conditions for solving quadratic programming, including the Lagrangian function and the Karush-Kuhn-Tucker conditions are explained in details in [1]. After the quadratic programming optimization problem has been solved, the features with higher weights are better variables to use for subsequent classifier training.

B. Conditions balancing

Depending on the learning problem, the two conditions can have different relative purposes in the objective function. Therefore, we introduce a scalar parameter α as follows:

$$Min f(\mathbf{x}) = \frac{1}{2}(1-\alpha)\mathbf{x}^T Q\mathbf{x} - \alpha F^T\mathbf{x}, \quad (5)$$

above $\mathbf{x}$, Q and F are defined as before and $\alpha \in [0,1]$, if $\alpha = 1$, only relevance is considered. On the opposing, if $\alpha = 0$, then only independence between features is considered that is, features with higher weights are those which have lower similarity coefficients with the rest of features. Every data set has its best choice of the scalar α. However, a reasonable choice of α must balances the relation between relevance and redundancy. Thus, a good estimation of α must be calculated. We know that the relevance and redundancy terms in Equation 6 are balanced when $(1-\alpha)\overline{Q} = \alpha\overline{F}$, where $\overline{Q}$ is the estimate of the mean value of the matrix Q; and $\overline{F}$ is the estimate of the mean value of vector F elements. A practical estimate of is defined as

$$\hat{\alpha} = \frac{\overline{Q}}{\overline{Q} + \overline{F}}. \quad (6)$$

IV. BASED INFORMATION THEORY SIMILARITY MEASURE

The information theory approach has proved to be effective in solving many problems. One of these problems is feature selection where information theory basics can be exploited as metrics or as optimization criteria. Such is the case of this paper, where we exploit the mean value of the mutual information between each pair of variables in the subset as metric in order to approximate the similarity among features. Formally, the mutual information of two discrete random variables x_i and x_j can be defined as:

$$I(x_i, x_j) = \sum_{x_i \in S}\sum_{x_j \in S} p(x_i, x_j) log \frac{p(x_i, x_j)}{p(x_i)p(x_j)}, \quad (7)$$

and of two continuous random variables is denoted as follows:

$$I(x_i, x_j) = \iint p(x_i, x_j) log \frac{p(x_i, x_j)}{p(x_i)p(x_j)} dx_i dx_j. \quad (8)$$

V. 5. EMPIRICAL STUDY

In general mutual information computation requires estimating density functions for continuous variables. For simplicity, each variable is discretized using Weka 3.7 software [4]. We implemented our approach in R using the quadprog package [10, 11]. The studied approach should be able to give good results with any classifier learning algorithms, for simplicity the logistic regression provided by R will be the underlying classifier in all experiments.

The generality of the feature selection problem makes it applicable to a very wide range of domains. We chose in this paper to test the new approach on two real word credit scoring datasets from the UCI Machine Learning Repository.

The first dataset is the German credit data set consists of a set of loans given to a total of 1000 applicants, consisting of 700 examples of creditworthy applicants and 300 examples where credit should not be extended. For each applicant, 20 variables describe credit history, account balances, loan purpose, loan amount, employment status, and personal information. Each sample contains 13 categorical, 3 continuous, 4 binary features, and 1 binary class feature. The second data set is the Australian credit dataset which is composed by 690 instances where 306 instances are creditworthy and 383 are not. All attributes names and values have been changed to meaningless symbols for confidential reason. Australian dataset present an interesting mixture of continuous features with small numbers of values, and nominal with larger numbers of values. There are also a few missing values.

The aim of this section is to compare classification accuracy achieved with the quadratic approach and others filter techniques. Table I and Table ii show the average classification error rates for the two data sets as a function of the number of features. Accuracy results are obtained with α= 0.511 for German data set and α= 0.489 for Australian data set, which means that an equal tradeoff between relevance and redundancy is best for the two data sets. From Table 1 and Table II it's obvious that using the quadratic approach for variable selection lead to the lowest error rate.

TABLE I. RESULTS SUMMARY FOR GERMAN DATASET, WITH 7 SELECTED FEATURES

	Test error	Type I error	Type II error
Quadratic	0.231	0.212	0.222
Relief	0.242	0.233	0.287
Information Gain	0.25	0.238	0.312
CFS Feature Set Evaluation	0.254	0.234	0.344
mRMR	0.266	0.25	0.355
MaxRel	0.25	0.238	0.312

TABLE II. RESULTS SUMMARY FOR AUSTRALIAN DATASET, WITH 6 SELECTED FEATURES

	Test error	Type I error	Type II error
Quadratic	0.126	0.155	0.092
Relief	0.130	0.164	0.099
Information Gain	0.127	0.163	0.094
CFS Feature Set Evaluation	0.126	0.165	0.098
mRMR	0.130	0.164	0.099
MaxRel	0.139	0.179	0.101

VI. CONCLUSION

This paper has studied a new feature selection method based on mathematical programming; this method is based on the optimization of a quadratic function using the mutual information measure in order to capture the similarity and nonlinear dependencies among data.

ACKNOWLEDGMENT

The authors would like to thank Prof. Mohamed Limam who provides valuable advices, support and guidance. The product of this research paper would not be possible without his help.

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A Comparative Study on different AI Techniques towards Performance Evaluation in RRM(Radar Resource Management)

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***Abstract*— The multifunction radar (MFR) has to make a decision as to which functions are to be performed first or which must be degraded or even not done at all when there are not enough resources to be allocated. The process of making these decisions and determining their allocation as a function of time is known as Radar Resource Management (RRM). The RRM has two basic issues: task prioritization and task scheduling. The task prioritization is an important factor in the task scheduler. The other factor is the required scheduling time, which is decided by the environment, the target scenario and the performance requirements of radar functions. The required scheduling time could be improved by using advanced algorithm [1, 6].**

Keywords- Radar; RRM (Radar Resource Management); Artificial Intelligence (AI); Neural Network (NN); Fuzzy Logic (FL).

I. INTRODUCTION

The term RADAR is an acronym for RAdio Detection And Ranging. RADAR's are used in detection and location of objects like spacecraft, aircraft, ships, vehicles, people and natural environment. It uses radio waves to detect objects or targets otherwise invisible because of distance from observer, darkness or naturally occurring barriers such as fog or cloud cover. In addition to detection, radar can determine the object's distance or range from the radar station, its position and its speed and direction of movement [1].

Multifunction radar is based on phased arrays and it is able to execute multiple functions integrated all together. Multifunction radar (MFR) performs many functions previously performed by individual, dedicated radars, such as search, tracking and weapon guidance, etc. The primary interest when looking at the operational efficiency of this type of radar system is to schedule the radar jobs effectively. A detailed functional simulation model, which generates a multifunctional radar environment, has been developed to aid the evaluation of the various scheduling algorithm [6].

Multifunction radar is the main sensor for modern weapon control systems. The radar consists of an electronic beam steering phased antennas and performs surveillance and tracking of multiple targets and simultaneous tracking and guiding of multiple missiles.

The advantage of a phased array radar system over mechanically scanned radar is the provision to put the beam at anytime by electronically switching the beam. This enables adaptive track updates, and instantaneous scheduling of urgent tasks such as confirmation of detection.

The multifunction radar (MFR) has to make a decision as to which functions are to be performed first or which must be degraded or even not done at all when there are not enough resources to be allocated. The process of making these decisions and determining their allocation as a function of time is known as Radar Resource Management (RRM). All the functions or the tasks are coordinated by a central component RRM in the radar system. This RRM component is critical to the success of a MFR since it maximizes the radar resource usage in order to achieve optimal performance [6, 8, 9].

II. LITERATURE SURVEY

A. *Introduction to AI techniques:*

In real systems, the use of a fuzzy logic method and neural network method may represent a useful support for radar resource management decisions. It is also very important that the information in respect of radar resource management is presented to the radar operator at all times [8, 9].

Fuzzy Logic is a logical system, which is an extension of multivalued logic. However, in a wider sense fuzzy logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp boundaries in which membership is a matter of degree [2].

Neural networks are composed of simple elements operating in parallel. These elements are inspired by biological nervous systems. As in nature, the connections between elements largely determine the network function. Neural network can be trained to perform a particular function by adjusting the values of the connections (weights) between elements [3, 4].

B. *The Radar Resource Management Problem*

There are two major radar resources: time and energy. The challenge of the RRM arises when the radar resources are not enough to assist all the tasks in all the functions. Lower priority tasks must encounter degraded performance due to less available resources, or the radar may not execute some tasks at all. Each task in the radar requires a certain amount of time, energy and computational resource. The time is characterized by the tactical requirements, the energy is limited by the transmitter energy, and the RRM limits the computational resource. All of those limitations have impacts on the performance of the radar resource management [1, 6,8, 9].

An additional challenge is that since the RRM deals with many radar subsystems, evaluation of the RRM algorithms must be done under a more complex and detailed radar model. A general MFR resource management system model is shown in Fig. 1. It performs the following steps:

• Get a radar mission profile or function setup;

• Generate radar tasks;

•Assign priorities to tasks by using a prioritization algorithm;

• Manage available resources by a scheduling algorithm so that the system can meet the requirements of all radar functions;

• The radar scheduler considers radar beams, dwell time, carrier frequency, and energy level, etc.

As can be seen from the above steps, the RRM problem has two basic issues: task prioritization and task scheduling. Some RRM algorithms handle the two issues separately and others handle them simultaneously. The task prioritization is an important factor in the task scheduler. The other factor is the required scheduling time, which is decided by the environment, the target scenario and the performance requirements of radar functions. The required scheduling time could be improved by using advanced algorithms.

A RRM algorithm can be non-adaptive or adaptive. In a non-adaptive scheduling algorithm, the task priorities are predefined and the radar scheduler includes some heuristic rules. Therefore, the resource perf

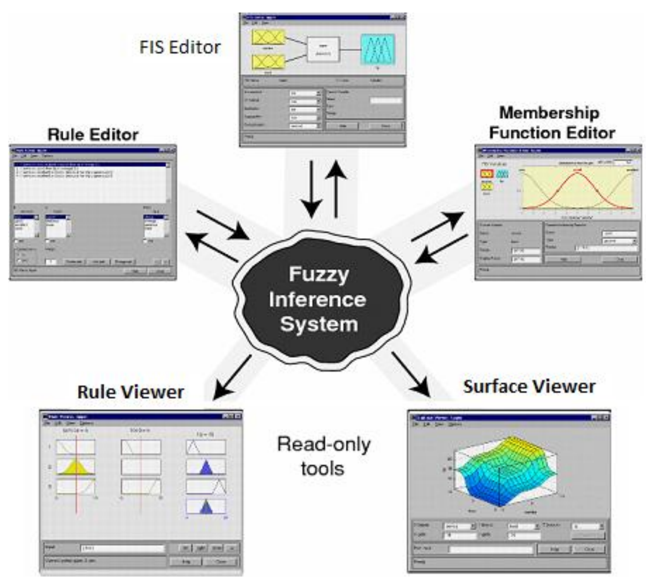

Figure 2. Fuzzy Inference System.

ormance is not optimized [6, 9].

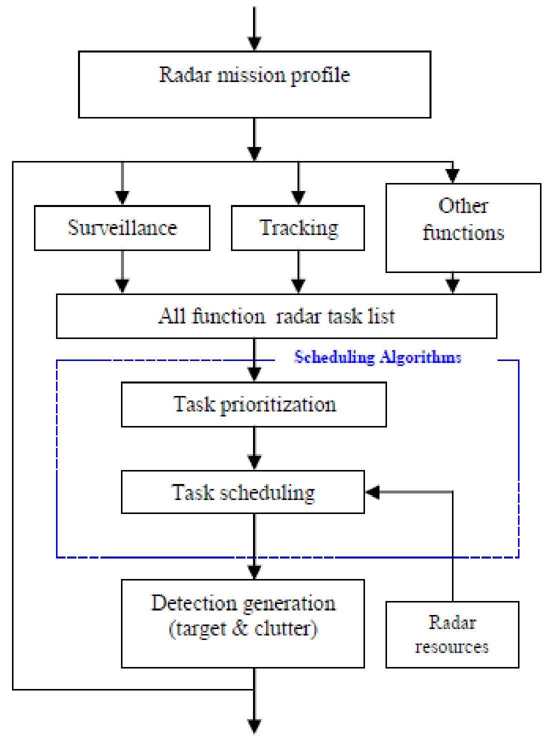

Figure 1. MFR Resource Management Model.

C. *Solution to RRM problem:*

Adaptive scheduling algorithms are much more complex, and should theoretically yield better performance. Advanced MFRs always use adaptive scheduling algorithms. One of the algorithm is Artificial Intelligence (AI) algorithm.

There are 2 algorithms under AI, which are used in task prioritization:

1. Fuzzy Logic Approach
2. Neural Network.

1. Fuzzy Logic approach: Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, which is an extension of multivalued logic. However, in a wider sense Fuzzy Logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp boundaries in which membership is a matter of degree. Fig. 2 shows the FIS (Fuzzy Inference System) that helps in formulating the mapping from the mapping from a given input to an output using FL [2].

2. Neural Network elements are as shown in Fig. 3. Neural networks are adjusted or trained such that a particular input leads to a specific target output [3, 4].

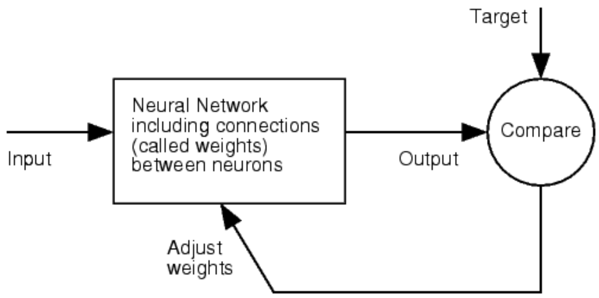

Figure 3. Neural Network

III. METHODOLOGY

A. Architecture

The system architecture is as shown in Fig. 4 that focuses on tracking, surveillance and task scheduling.

The various functions of the system architecture are as discussed in the following section.

a. Surveillance function: Based on the information and on the desired surveillance performance, the surveillance function calculates the number of radar beams necessary to survey that volume. A list of task requests is generated, taking into account the desired surveillance performance of the radar system. The surveillance manager is fed by the task list, maintained an inactive queue of tasks (not yet scheduled), and provides the scheduler with a smaller queue of requests that are close to their due time of execution.

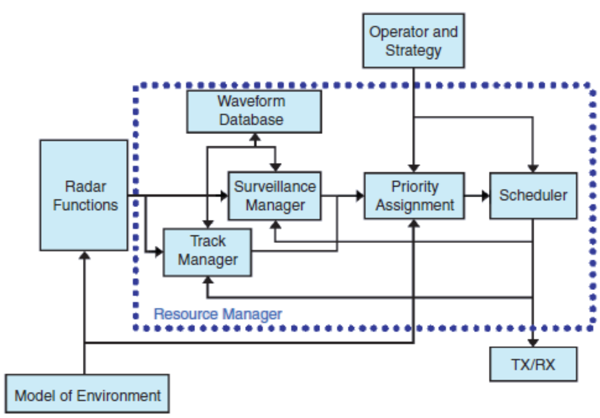

Figure 4. System architecture

b. Track function: calculates the update times of the targets under track and feeds the track manager with a queue of tasks to be scheduled. The track manager also maintains a list of inactive track tasks that are to be sent to the scheduler when close to their due time of execution.

c. Waveform Database: Both surveillance and track manager select from the waveform database the parameters to be used in the transmission of the radar pulses associated with each radar job.

d. Priority Assignment: Decisions relating to how resources are to be allocated according to the relative importance of the tasks and how to assess this relative importance are made by priority assignment block. Here 2 methods are discussed for prioritizing tasks. 1. Prioritization using fuzzy logic. 2. Prioritization using Neural Networks.

e. Scheduler: It is fed by queues of track, plot confirmation, surveillance task requests and creates a set of measurement tasks to be carried out by the radar based on task priorities and time constraints. A feedback loop between the output of the scheduler and the radar functions enables the next update times related to those tasks to be calculated.

f. Operator and Strategy: This module operates as a human-machine interface, allowing intervention to enable corrections in the behavior of the system [8].

B. Prioritization using Fuzzy Logic and Neural Network:

The attribution of priority to regions and targets of interest is central to the eventual performance of the radar system and to subsequent mission success. There are a variety of methods that may be employed, from simple fixed allocations based on operational experience to more elaborate schemes that attempt to balance competing components that constitute the overall determination of priority. The priority for tracking targets may be evaluated using the decision tree presented in Fig. 5. This could be carried out according to information provided by a tracking algorithm, by other sensors, or by other operational modes of the multifunction radar [6, 9].

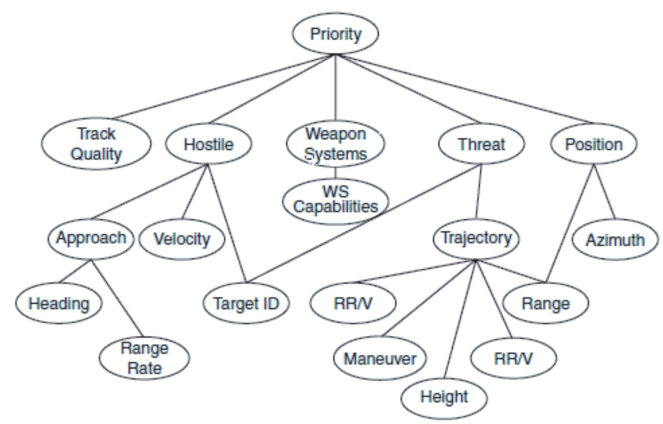

Figure 5. Decision tree for target priority assignment.

Some examples of the fuzzy values are presented in Table I. Five different variables provide information used to set the priority level. These are threat, hostility, quality of tracking and relative position of the target, and weapon system capabilities of the platform. After evaluation of these variables according to a set of fuzzy rules (i.e. FIS is constructed at each level of the tree) the importance (priority) of the target is determined [6, 9, 13].

TABLE I. FUZZY VALUES RELATED TO THE MAIN VARIABLES USED IN THE PRIORITY ASSIGNMENT.

Fuzzy Variable	Fuzzy values
Track Quality	High and Low
Hostile	Nonhostile, Unknown And Hostile
Weapon Systems	Low And High Capability
Threat	Low, Medium ,High And Very High

Position	Close, Medium And Far
Priority	Low, Medium, High And Very High

A similar methodology is applied to the surveillance function base upon the decision tree presented in Fig. 6. In this case, the priority of surveillance sectors may be assessed through the original priorities attributed to the regions with respect to the expected tactical scenarios and the information gathered during the evolution of the actual environments. This includes aspects such as rate of detection of new targets, number of threatening targets, and rate of detection of new threatening targets. A set of fuzzy rules (a FIS) enables the evaluation of the priority of the different sectors considered for surveillance [9, 13].

Figure 6. Decision tree for sectors of surveillance priority assessment

In Neural Network approach a Neural Network is constructed at each level of the decision tree (shown in Fig. 5) and the output is fed to the next higher level. This process repeates till priority of the target is calculated. To calculate the priority of sector of surveillance one Neural Network is used [2].

C. Performance Evalution

By knowing the identity of the targets, their priorities may vary. This provides valuable information to be accounted for when deciding how to allocate radar resources in overload situations. Three targets are assumed in the analysis, their probabilities of being enemy are different as follows: 1 (enemy), 0.5 (unknown), and 0.1 (friendly), corresponding to the red, blue, and green curves, respectively. The probabilities of targets are kept constant. The evolution of the resulting priorities is shown in Fig. 7 and Fig. 8 for 50 radar scans, which shows that, in general, all priorities increase as the targets move towards the radar platform and the greater the probability of being enemy, the greater the resulting priority.

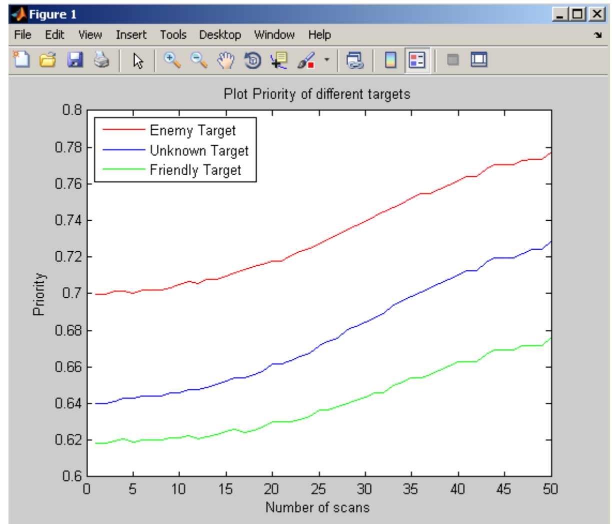

Figure 7. Priorities of 3 targets using Fuzzy logic

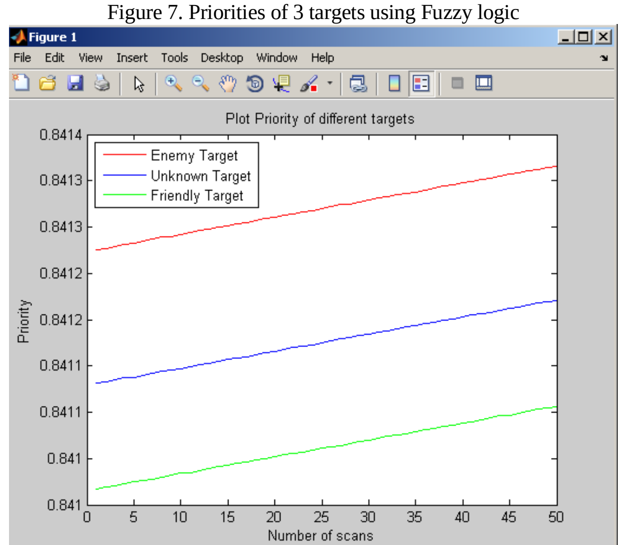

Figure 8. Priorities of 3 targets using NN

Fig.7 and Fig. 8 presents the results of a priorities calculated where targets are assumed to move on a straight line trajectory with constant velocity. From the first scan onwards priorities of targets calculated using neural network is high compare to priorities obtained using fuzzy logic.

At first, there is a tendency to consider that if two systems execute the same set of tasks, the system that assesses these tasks with lower priority should be considered more effective, because fewer resources would be allocated to execute the tasks. The task priority, therefore, is important for preparing the set of measurements to be executed by the radar. Fuzzy logic approach and neural network approach for prioritizing radar tasks in changing environment conditions is introduced. Results suggest that the fuzzy approach is a valid means of evaluating the relative importance of the radar tasks; the resulting priorities have been adapted by the fuzzy logic prioritization method [6, 8, 9, 13].

CONCLUSION

Prioritization is a key component to determine overall performance. Performance of two scheduling methods is compared. Fuzzy logic suggests that fewer resources can be allocated to execute tasks, which is more important for radar to manage resource. Fuzzy approach has operational advantages particularly under stressing conditions, which is important in design of RRM.

In future other AI techniques, such as an entropy algorithm and Expert System Approach can be used to evaluate performance of RRM based on neural networks and fuzzy logic techniques.

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Integrated Information System of Monitoring and Management for Heart Centers

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***Abstract*— The integrated information system presented in this paper is focused on increasing the quality of the medical services offered to the patients by rendering the activities more efficient and by corroborating the family doctors and the cardiologists' efforts. In order to accomplish the mentioned objectives we propose implementing an integrated information system by means of which the integrated management of the medical data will be done. In addition, it has been offered a collaborative instrument, patient oriented, that it will be used both by the family doctor and by the specialist doctor.**

Keywords- ECG; Monitoring; Management; Integrated Information System.

I. Introduction

According to the World Health Organization [1], the cardiovascular diseases are considered to be the leading cause of death in the world. According to the same WHO report, the countries with a low and medium standard of life are seriously affected in comparison with the rest of the states, registering a cardiovascular disease death rate of 82%. In Romania, deaths caused by the cardiovascular diseases are on the first place and Rumania is on the 4th place among the European countries, first place being taken by Russia, the second one by Bulgaria and the third one by Hungary. Taking into consideration these statistical data, a medical management is necessary in order to offer the cardiovascular diseases treatment a special place. The extension of the cardiac medical services to the rural areas, where no medical personnel specialized in cardiology can be found, represents a possible solution.

The cardiovascular diseases represent the most frequent cause of death in the economically developed countries, with a rapid ascendance, mostly in those in the developing process. It is appreciated that from 55 millions deaths registered in the world annually, approximately 30% are caused by the cardiovascular diseases. The mortality curve due to this disease registered in the last years a great difference between Central and Easter European countries – where it reached a high pick and the Northern and Western European countries – where it is dropping. [1]

To a world level, we can estimate that there are a total of 1.5 milliard adults with high blood pressure, which represents 333 millions cases in developed countries and 639 million cases in developing countries. Taking into consideration that 80% of the world population live in developing countries we can appreciate that the world prevalence of HBA will increase from 20% to 30% in the next years. The 2002 report of the World Health Organization appreciates that over 50% of the coronary diseases and approximately 75% of the strokes are due to increased systolic BP over the minimum theoretical value of 115 mmHg. [2]

Most recently, the INTERHEART study estimates that almost 22% of the acute coronary syndromes in Western Europe and 25% in Central and Eastern Europe are due to the high blood pressure, emphasizing that the patients with HBP have a double risk of suffering an acute coronary event than the people with normal BP.

The paper initiates the presentation of an integrated information system dedicated to electrocardiographic records, by means of which the medical data management is to be improved based on a patient-oriented collaborative instrument that can be used in common by family doctors and cardiologists.

II. Informatic System Architecture And Functional Description

The proposed information system has a modular architecture with specific functions for every module. Thus, the proposed structure (presented in Figure 1) consists in the following three software modules:

1. ECG Cabinet Module
2. ECG WS Module
3. ECG Monitoring Module

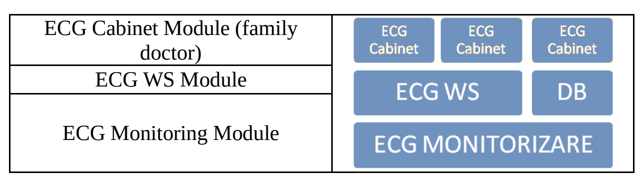

Figure 1. The Structure of Integrated Information System of Monitoring and Management

The information system should run distributed as follow:

- In the family doctor cabinet, as a distinct module (**ECG cabinet**) installed on a computer or laptop connected to an ECG device; ECG device will be controlled by means of this module; the results of the ECG investigation will be recorded and associated automatically with the patient. Initially data related with ECG investigations will be stored locally in a first phase, in a database; If an Internet connection is available, the results of the ECG investigations will be transmitted automatically to a central server for parallel processing and monitoring;

- On a central server (ECG WS and DB - **Web Server and Database**), where the centralization, the aggregation and the running of previous diagnosis algorithms and alerts on the base of the results of the received investigations will be carried out;
- In the permanent monitoring centre (**ECG Monitoring**), data regarding the patients for whom the investigation results were received together with the eventual alerts regarding the possible patient's pathology, alerts generated by the central server. The functional design of the proposed system is presented in the Figure 2.

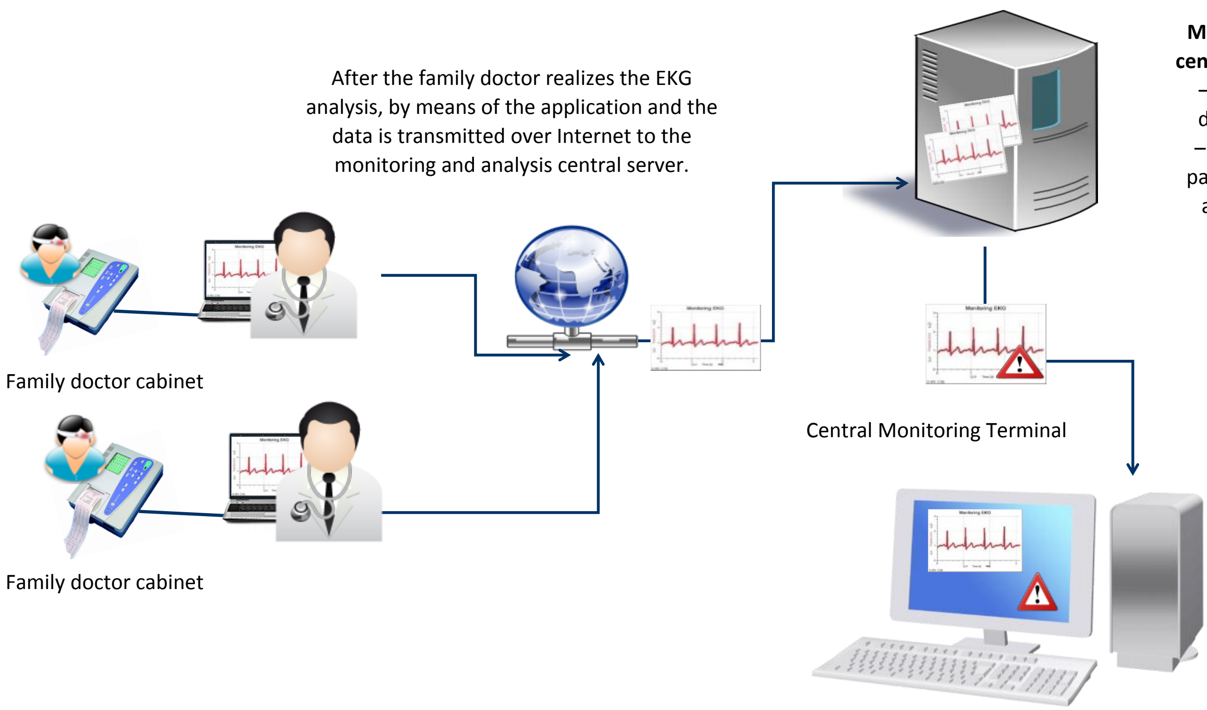

Figure 2. The functional design of the Integrated Information System

A. *ECG Cabinet Module / Family Doctor (FD)*

This software component is a desktop application designed to run on a computer from the family doctor's cabinet. The role of this component is to maintain records on the patient medical record, to record output results of the ECG medical equipment, in electronic format, and associate them with the patient medical record followed by the immediate transmission of this data to the monitoring centre.

1) *Necessary configurations*

- Installing the application on the computer in the family medicine cabinet
- Connecting the application to the medical equipment by means of the serial cable which connects the device with the computer where the application runs;
- The serial port configuration
- Installing the security certificate allocated to the family doctor

2) *The main functionalities*

- Maintaining the patient medical record;
- Communicating with the help of the medical equipment for ECG investigations ;
- Synchronous recording of the ECG investigation results and their automatic association with the patient medical record and his/hers medical history.
- Displaying the investigation results having the possibility of making various analyses on data by means of rescaling and measuring of the signals.
- Transmitting data that refers to the patient medical record and the investigations made in order to synchronize with a central database.
- Automatically receiving from the monitoring centre of possible specialist doctors' warnings and recommendations and this data to the patient medical record and the referred investigations.

- Receiving the patient medical history from the central database. This medical history can be the result of past investigations, in other cabinet.

3) Integrations

- With a medical equipment to realize ECG investigations by means of a direct serial cable internet connection of the equipment to the computer where the software runs;
- With the central service for data synchronization - ECG WS – using the internet connection and last generation communication technologies based on web services.

4) Using technologies

In order to develop this software component last generation, software technologies that assure its compatibility with the last generation operating and calculation systems were used, as well as, the necessary minimal knowledge for realizing this configuration for using it.

For communicating on the Internet web service technologies are used in order to synchronize with the central data base, using standard communication protocols that proved their efficiency by their implementation with other public systems.

5) Data security

In order to assure the confidentiality of the personal data and the investigation results, during the transmission of these data to the central database, crypting and data integrity assurance technologies are used.

For the system access, for every doctor a digital certificate will be generated by means of which he/she will be identified in the system and will be able to encrypt the transmitted data.

In addition, a medical history will be maintained with the activity of each user in the system on the base of which statistical analyses can be made for identifying some possible intents to compromise the data.

*B. **ECG WS Module***

This component of the information system will be installed on a server that will represent the data confluence place of all the family doctor cabinets, data that will be stored on this server in a database. Immediately after receiving, the data will be offered to the specialist doctors by means of ECG Monitoring Module. Besides the expected data (patient medical record + the realized investigation in electronic format), the system will generate some alerts as a consequence of a pre-processing process and possible pathologies identification.

1) The main functionalities

- The management of the access right inside the system.
- Certifying and authorizing the system users
- Communication with ECG Cabinet applications installed in the family doctor cabinets for receiving the patient medical records and the realized ECG investigation results.
- Storing data in the database.
- Realizing pre-processing operations to identify the possible pathologies and alerts sent to the specialist doctor.
- Synchronous Data Transmission to the ECG Monitoring Component operated by the specialist doctor.
- Specialist doctor generated messages transmission to the ECG Cabinet referring to an investigated patient.
- Maintaining access and activity logs inside the system.

2) Integrations

- With the ECG Cabinet module, by means of an Internet connexion for undertaking the patient medical record and the ECG investigation results;
- With the ECG Cabinet module, for transmitting to the specialist doctor the investigations received from the family doctor;
- With the ECG Cabinet module, for transmitting the reply of the specialist doctor to the family doctor.

3) Using technologies

JAVA, J2EE, AXIS WS, SQL

*C. **ECG Monitoring Module***

This software component is implemented under the form of a desktop application that runs on one or several computers inside the monitoring centre [3- 8]. By means of this application, the specialist doctor has access to the medical record data, the current ECG investigation as well as to the history of all ECG investigations made for the patient in the past, no matter the place where these were realized (another family doctor). The specialist doctor by means of these software instruments has direct access to software instruments to visualize and analyze the investigation result based on which he/she can make recommendation or warnings that can be instantly transmitted to the family doctor cabinet where the specific investigation was made.

1) Extensibility. Regionalization

According to the number of family medicine cabinets registered in the system and the intensity of their activity, with the object of maintaining the efficiency of the answering time, it is possible the allocation of specialist doctors depending on groups of cabinets, the allocation criteria being dynamic (region, locality, area, etc.). Thus, each specialist doctor will receive on his/hers screen only the messages of the cabinets assigned to that.

2) Automat signal processing and alert engendering

When receiving the results of an ECG investigation on the central server these data pass by some pre-processing operations by means of which the following activities are carried out:

- The detection of the R wave with the object of subsequent annotation of the diagram seen by the specialist doctor. [9]

- The cardiac frequency calculation with the emission of warnings on a frequency higher than 130 beats per minute or lower than 40 beats per minute.
- The variability cardiac rhythm calculation on a number of 6-8 cardiac complexes. The engendering of warnings at variability 20% higher or lower, together with graphically marking the specified area.
- QRS complex detection [10]
- Medium term calculation of the QRS complex. Warning engendering at a average value of the QRS complex term bigger than 120 ms.
- The detection of the S, T and P waves with the beginning and the end of these waves.
- Warning at a medium value of the ST segment 2 mm bigger than the izoelectric line or 2 mm smaller than the izoelectric line.
- Heart beat classification and graphical display according to following classes: 0 = Atrial premature beat, 1 = Normal beat, 2 = Left bundle branch block beat, 3 = Right bundle branch block beat, 4 = Premature ventricular contraction, 6 = Fusion of ventricular and normal beat, 8 = Paced beat, 9 = Fusion of paced and normal beat

3) The main functionalities

- The download from ECG WS of data regarding the patient's medical record and the investigation results;
- Displaying the data resulting from the pre-processing made on the central server based on priorities resulted after establishing an emergency degree;
- The specialist doctor offers instruments to analyze and process the ECG investigation result (amplitude scaling, time, QRS detection, measuring).
- The registration of observations, recommendations and warnings of the specialist doctor and their registration by means of ECG WS to the family medicine cabinet where they would be automatically displayed in the ECG Cabinet.

4) Integrations

With ECG WS for taking over the data related with the patient's medical record, the investigations result and for transmitting the observations, recommendations and warnings related to current investigation to the family doctor.

D. Data transfer design

The general patient-oriented intercommunication diagram is presented in the figure 7, where the family doctor takes from the patient the necessary data for filling in the medical record, together with the ECG registration, and transmits them to the cardiologist along with a message containing questions and comments related to the patient' situation. The specialist doctors evaluate the received data and answers the questions and/or prescribe a treatment scheme or specifies the necessary additional investigations.

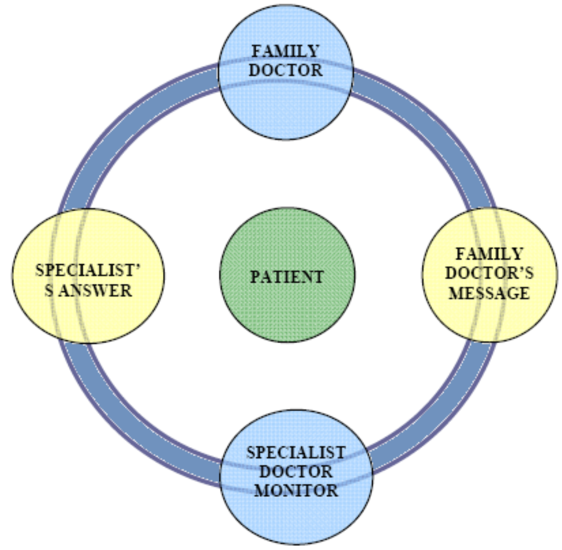

Figure 3. Patient-oriented communication

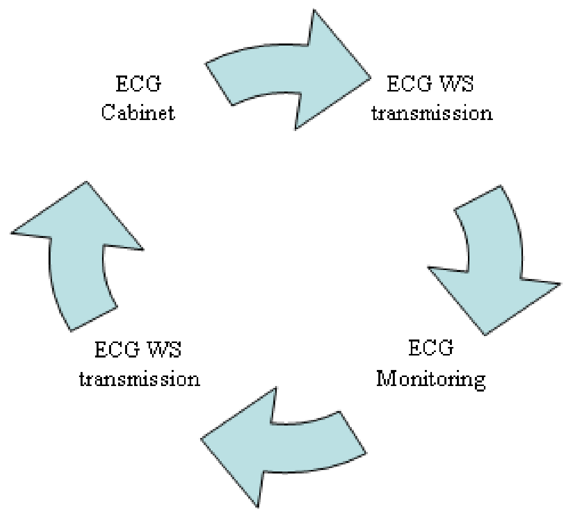

Figure 4. Communication between the information system components

The main intercommunication characteristics (data transfer) are the following:

- Data transfer to the CENTRAL server is done respecting the in force standards regarding the data security assurance; For this encryption algorithms based on public/private key are used;
- Any data transmission between the family doctor cabinet and the central server is made after a previous authentication of the transmitter's identity;
- The data transfer is made taking into consideration the restrictions regarding the quality of the available internet connection from the family medicine cabinets;
- The data transfer from the family medicine cabinets to the CENTRAL server is made using data blocks of

configurable sizes according to the known quality of the speed and available internet connection stability;

- This solution is absolutely necessary for implementing the transmission return functionality in case of scenarios like:
    - Low Speedy Internet connection;
    - Instable Internet Connection;
    - Transmitted data sample of relatively big size (2 – 3 MB);
- The minimum size of the data block is established to 10 KB;
- Data retransmission will be resumed till the confirmation of receiving it on the CENTRAL server;
- After the complete reception of data on the CENTRAL server it will be processed in order to transfer the registrations into the database;

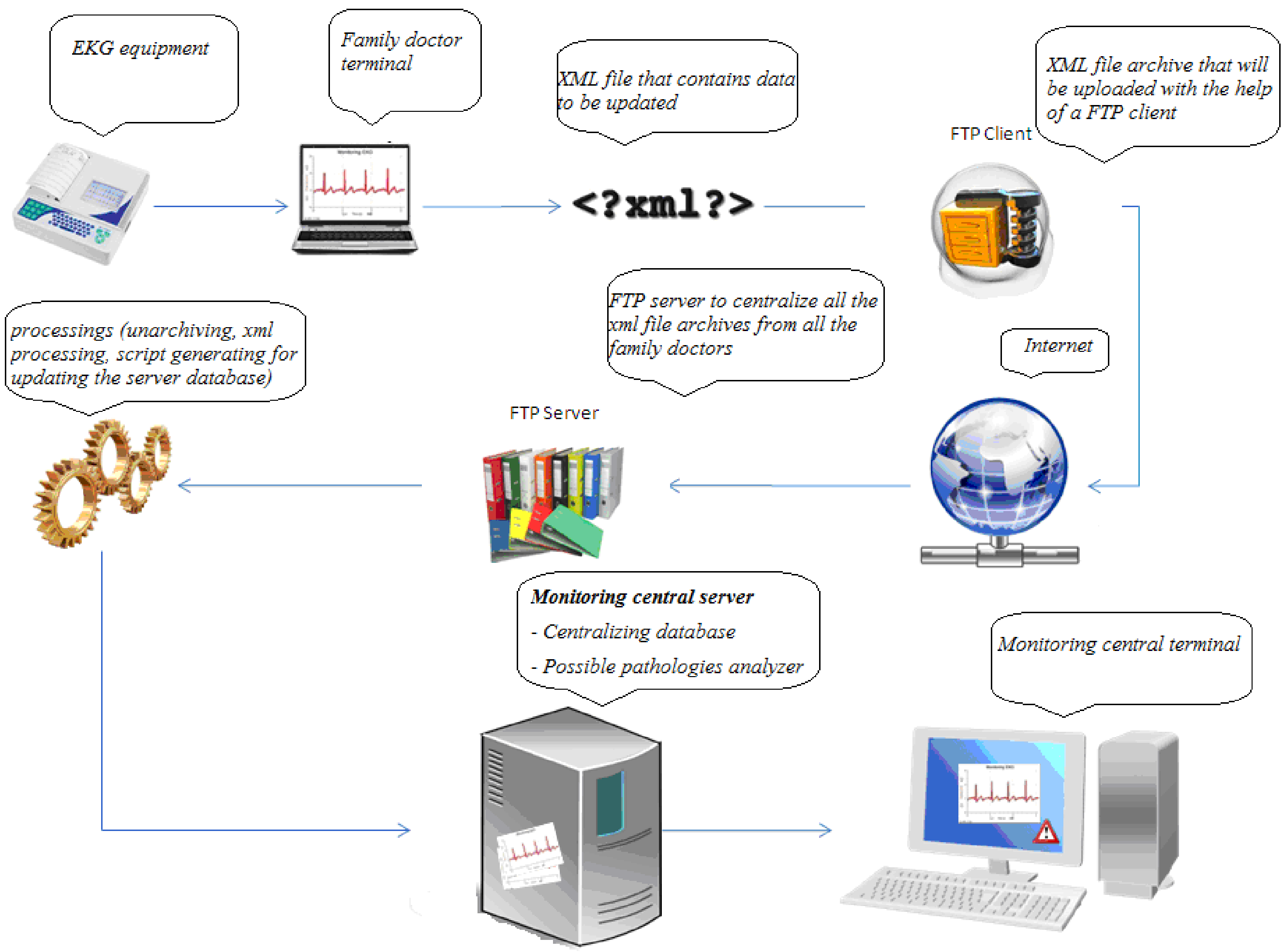

Figure 5. General intercommunication scheme

1. The ECG equipment is controlled by means of the ECG cabinet with the purpose of achieving the ECG investigation and collecting within the database the investigation results.
2. When the application is synchronized, an xml local file is created which contains the necessary data for updating the information from the server (patient information, investigation information, doctor information). A record regarding the date/hour of synchronization is saved in the database, thus being able to reproduce a history of synchronizations. Observations regarding the file structure:

- In order to optimize the data transfer, the xml will; have to have a dimension as reduced as possible.
- The file contains only patients who have modified data, who have registered new investigations or who were not synchronized at all on the server (new patient).
- The file contains only the investigations which are not synchronized on the server (new record)

- Within the <graphic> are saved all the points that outline the ECG graphic, separated by the “#” separator.

3. The xml saved file is archived with the help of an archiver (Win Zip, Win Rar). The result is a file of archive type which has a much smaller dimension than the previous one (We can obtain an archive with a 7 times smaller dimension)

4. With the help of a FTP client (File Transfer Protocol) the transfer occurs from the computer/laptop which has installed the ECG cabinet (MF) module, with the help of the internet connection, on the FTP server which is located on the machine that has the COLLECTION/ANALYSIS Module installed. Through this type of server, the archive reaches the server safely. In the case that the internet connection is unstable, the synchronization is resumed from where it had stopped when the internet connection is reestablished. The data is encrypted by means of SSL protocole. For this encrypting 2 keys are necessary: a public one that everybody knows and a private one known only by the server.

5. After the synchronization, the data reaches the server. Here are centralized all the archives coming from all the ECG cabinet (MF) terminals. The files on this folder have unique names composed of the national identification number of the Family Doctor whose data concerning the patients are synchronized as a suffix and the date and hour when the synchronization occurs. The files that are transferred in totality and processed receive the “_T” prefix which indicates that the data from this archive was synchronized and are kept as back-up.

Example

1650921336402_27_09_2010_17_58_22.zip

1700201256213_01_06_2010_12_01_33_T.zip

6. When an archive is transferred in totality on the server, the file processing begins. The xml file is unachieved. The latter is placed and with the information it contains, the insert and update scripts are created. The scripts are run in the server database and have the role to save the new data come from the ECG cabinet terminal (MF).

7. The data automatic analysis algorithms are created. They detect the eventual anomalies within the investigations corresponding to the newly synchronized patients and save in the database new records corresponding to the pre-diagnostic.

8. On the live monitoring interface, the new patients synchronized in the order of pathologies priority will appear. Visual and sound alerts are transmitted to attract the attention on the cases that require immediate attention.

III. Conclusions and Future Work

The information system presented in this paper and which has as purpose improving the management of medical information by increasing the quality of the medical services offered to the patients supposes a series of activities and namely:

- Generating information instruments of doctor’s assistance in the interpretation of the electrocardiograph investigations results
- Generating and maintaining a centralized patient history from the point of view of the disorders and investigations carried out;
- Implementing a collaborative instrument usable by the family doctors and the specialist cardiologist physicians through which the medical information is efficiently disseminated in the patient’s interest;
- Implementing certain signal processing dedicated to the ECG signals with the purpose of identifying the possible pathologies and issuing warnings to the specialist doctor and the family doctor
- Generating a centralized medical database.

In future, we intend working with as many medical centers to implement the presented system and customize the application according to specific requirements of each center.

Acknowledgment

This work has been supported by the Greensoft Ltd. company, Romania.

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ICOFL: An Alternative Design Approach to an Intelligent Change Over System Based on Fuzzy Logic Controller for Domestic Load Management

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Abstract— **This paper discusses the development of a model of an intelligent changeover fuzzy logic switching system (ICOFLS) for domestic load management. The presented model combines the benefits of fuzzy logic controller (FLC) and vector-control in a single system controller. High quality of the regulation process is achieved through utilization of the fuzzy logic controller, while stability of the system during transient processes and a wide range of operations are assured through the application of the vector-control in the fuzzy logic controller. The hybrid controller has been tested by applying it to the management of three major entities in its rule base: Phase lines, Generator system and Inverter system. The MATLAB Simulink fuzzy logic blockset was used in this research for the proposed model while proteus ISIS was used to depict a simulation process model and real time application. Input variable and output variables were defined in the work using the mamdani fuzzy inference structure for the system algorithm developed.**

Keywords- ICOFLS;FLC;Utilization;Rule base;FIS.

I. Introduction

All The traditional approach to building system controllers requires a prior model of the system [1]. Although fuzzy logic deals with imprecise information, the information is processed in sound mathematical theory [1].Loss of precision from linearization and/or uncertainties in the system's parameters can negatively influence the quality of the resulting control.

Based on the nature of fuzzy human thinking, Lofti Zadeh originated the "fuzzy logic" or "fuzzy set theory", in 1965. Fuzzy logic deals with the problems that have fuzziness or vagueness. According to [2], Many real-world applications can be implemented by fuzzy set theory rather impossible to represent in classical theory. For this reason fuzzy logic is often defined as multi-valued logic (0 to 1), compared to bi-valued Boolean logic [3].

Fuzzy logic attempts to systematically and mathematically emulate human reasoning and decision making. It provides an intuitive way to implement control systems, decision making and diagnostic systems in various branches of industry. Fuzzy logic presents a thin close gap between human reasoning and computational state logic. Variables like high, medium, normal, big and small employ subjectivity as well as uncertainty in context.. Though they cannot be represented as crisp values, however their estimation is highly desirable. Fuzzy systems are emerging technologies targeting industrial applications and added a promising new dimension to the existing domain of conventional control systems [4]. Fuzzy logic allows engineers to exploit their empirical knowledge and heuristics represented in the IF-THEN rules and transfer it to a functional block. Fuzzy logic systems can be used for advanced engineering applications such as intelligent control systems, process diagnostics, fault detection, decision making and expert systems [2].

As such, this work leverages on the intelligence offered by fuzzy logic controller to develop a model of an intelligent changeover system (ICOFLS) that will monitor phase lines, generator plant and inverter system alongside with their corresponding parameters and effectively switches loads based on the prevailing system conditions. The proposed model is developed with MATLAB fuzzy logic block set and the appropriate process and control variables defined for effective load management.

II. Related Works

A detailed study on various works on fuzzy controller based systems was carried out in [4][5],[6],[7],[8],[9],[10]. However, a close attention was given to the work in [4],[6] which explores on applicability of fuzzy logic to tackle process controllers. In [6], methods of soft computing such as fuzzy logic, possess non-linear mapping capabilities which do not require an analytical model and can deal with uncertainties in the system's parameters.

The work in [10], focused on the design of a fuzzy controller that requires more design decisions than usual, particularly regarding rule base, inference engine, defuzzification, and data pre- and post processing. The work identifies and describes the design choices related to single-loop fuzzy control as well as design approach for proportional integral derivative (PID) controller as a starting point. However, previous work have discussed fuzzy logic but not in the context of domestic load control.

Besides, existing systems works on crips logic state making them to have a narrow scope in their functionality. This work focused on the Mamdani fuzzy inference system [4] to develop the proposed model. The Mamdani architecture is the way to design a fuzzy control system because it accurately handles the control processes of the informal nature of any control design process and systems.

A. *Fuzzy Logic Justification*

This paper stipulates a list of general observations about fuzzy logic as discussed in [3]:

- Fuzzy logic is conceptually easy to understand. The mathematical concepts behind fuzzy reasoning are very simple. It is a more intuitive approach without the far-reaching complexity.
- Fuzzy logic is flexible. With any given system, it is easy to layer on more functionality without starting again from scratch.
- Fuzzy logic is tolerant of imprecise data. Fuzzy reasoning builds this understanding into the process rather than tacking it onto the end.
- Fuzzy logic can model nonlinear functions of arbitrary complexity. This process is made particularly easy by adaptive techniques like Adaptive Neuro-Fuzzy Inference Systems (ANFIS), which are available in Fuzzy Logic Toolbox software.
- Fuzzy logic can be built on top of the experience of experts. In direct contrast to neural networks, which take training data and generate opaque, impenetrable models, fuzzy logic lets you rely on the experience of people who already understand your system.
- Fuzzy logic can be blended with conventional control techniques. Fuzzy systems don't necessarily replace conventional control methods. In many cases fuzzy systems augment them and simplify their implementation.
- Fuzzy logic is based on natural language. Because fuzzy logic is built on the structures of qualitative description used in everyday language, fuzzy logic is easy to use.

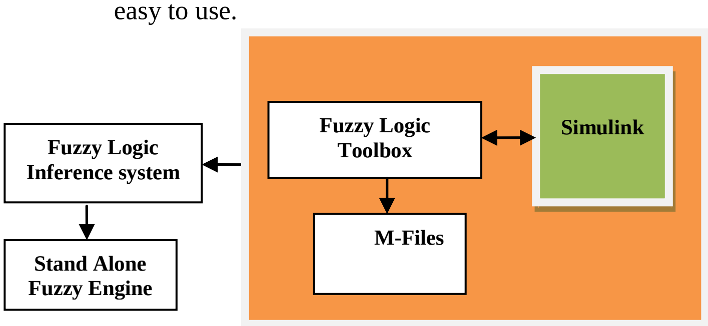

Fig. 1: MATLAB Integration Framework

This work discusses a proposed model of an intelligent change over switching system based on fuzzy logic algorithms for use in fuzzy logic controller using MATLAB Simulink software package to solve non-linear control problem in our context: a Model of an intelligent change over switch for control of switching sequences between PHCN phase lines, Generator and battery inverter system and its corresponding loads. Also Proteus ISIS software was used in this research to depict and demonstrate the system control simulation model.

III. Methodology

A. *System Model*

The high performance ICOFLS architecture is shown in figure 2. It assumed that the fuzzy logic controller has the complete capability to coordinate between the process variables and the control variable in this work. At the core of the proposed ICOFLS is a fuzzy logic controller which acts as a distribution medium for all process and control variables defined in this work. It serves as the management framework for the entire model. This paper practically details the implementation methodology as well as discusses the ICOFLS mechanism in the section 5.

B. *Goals*

In designing our proposed ICOFLS, the main goals are to maintain throughput while executing intelligent routines in the rule base and to create a robust system that is scalable, flexible and quick to deploy at anytime with less administrative overhead. Figure 2 below shows the proposed system model.

As shown in Figure 1, the core of the ICOFLS comprises of fuzzification block, rule base, inference engine, and defuzzification blocks. Starting from the inputs in the block diagram in Figure 2, the controller is between a pre-processing block and a post-processing block. The Pre-processing Engine conditions the inputs from A, B, C before they enter the controller. In this context, normalization is done here making the controller multi-dimensional, which requires many rules. The pre-processor then passes the data on to the controller. The Fuzzification Block then converts each piece of input data to degrees of membership by a lookup in one or several membership functions. The fuzzification block thus matches the input data with the conditions of the rules to determine how well the condition of each rule matches that particular input instance. The Rule Base handles multi-input-multi-output (MIMO) system whose control objective is to regulate some processes output around a prescribed set point or reference. In this research, a rule base mapping for the universe of discourse is developed in the rule editor of the MATLAB fuzzy rule editor.

Every element in the universe of discourse (PHCN, Generator, and Inverter Parameters) is a member of a fuzzy set to some grade. There are different types of membership functions (MFs) viz: S-function, π-function MF, Triangular MF, Trapezoidal MF, Rectangle MF, and Singleton MF [3]. There are two types of fuzzy inference systems that can be implemented in the Fuzzy Logic Toolbox: Mamdani-type and Sugeno-type [4].

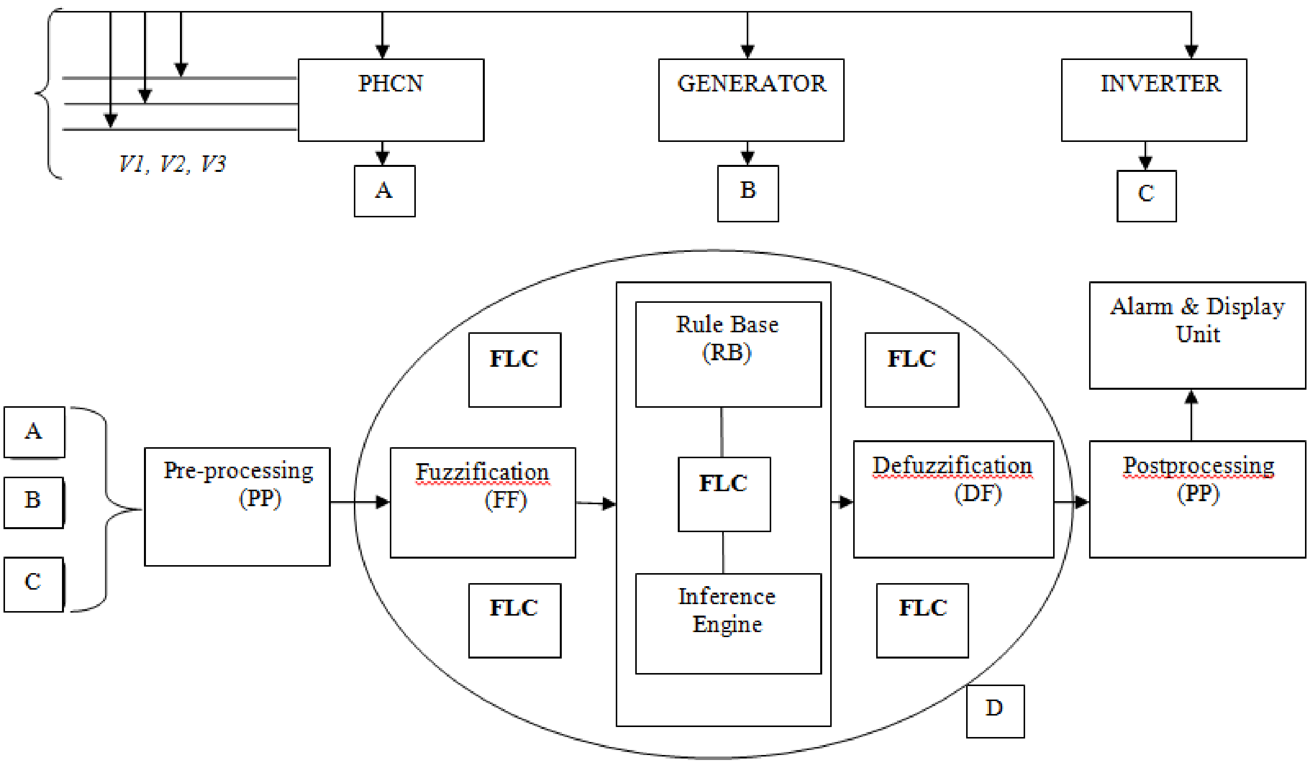

Fig. 2: System Architecture (ICOFLS)

These two types of inference systems vary somewhat in the way outputs are determined. This work adopted the former. Defuzzification converts the resulting rule base and inference engine to a number that can be sent to the process as a control signal. Post-processing performs an output scaling function for the defuzzified signals.

The methodology adopted in this paper in view of the modeling involves fuzzy Process modeling with MATLAB Simulink blockset while the model simulation is was done with proteus ISIS.

C. ICOFLS PROCESS SIMULATION MODEL WITH PROTEUS ISIS

Proteus ISIS software package was adapted in developing the ICOFLS. In this model, the phase lines, generator, inverter entitites were well represented as shown in figures 3. The fuzzy logic language was used in generating the fuzzified and defuzzified variables. For the phase lines, the fuzzy logic states were defined as low voltage (LV), medium voltage (MV), normal voltage (NV), high voltage (HV) (linguistic variables) with the membership functions appropriately defined in the membership editor of the MATLAB fuzzy blockset. The generator fuel level, oil level and water level are also shown as well as the inverter system status. Figures 3 show the ICOFLS simulation model with proteus ISIS package.

IV. MAMDANI FRAMEWORK FOR ICOFLS

In modeling the ICOFLS, this work adopted the fuzzy Logic Toolbox in MATLAB software designed to work in Simulink environment. After creating the fuzzy systems using the GUI tools, the system is then ready to be embedded directly into a simulation. The FIS Editor displays general information about a fuzzy inference system. Mamdani-type inference, as we have defined it for the Fuzzy Logic toolbox expects the output membership functions to be fuzzy sets. After the aggregation process, there is a fuzzy set for each output variable that needs defuzzification. The system reference the rule base and inference engine to make intelligent decisions.

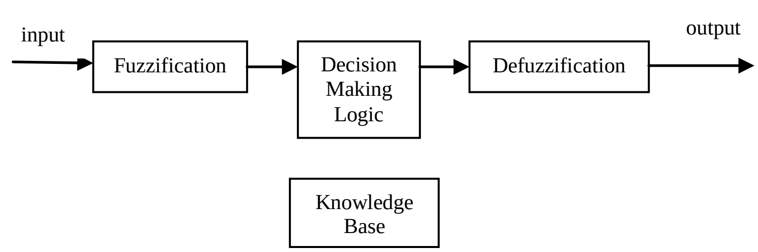

Fig. 4: Fuzzy Controller Block Diagram

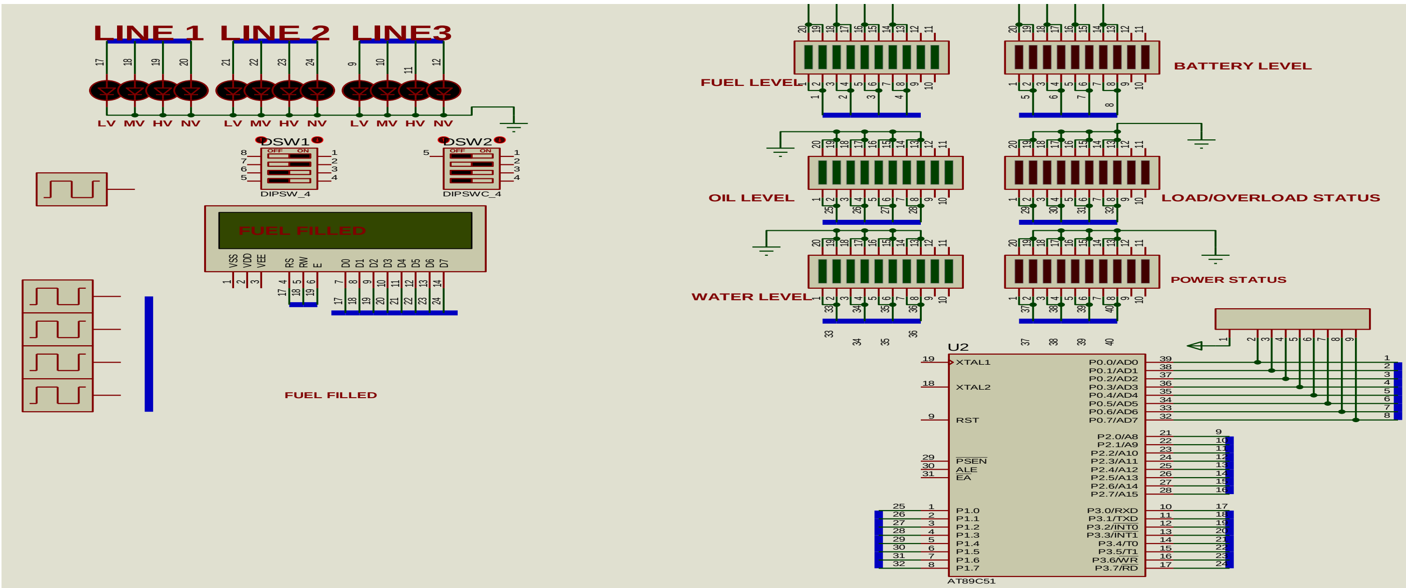

Figure 3: The ICOFLS Simulation model

In order to process the input to get the output reasoning, there are six steps involved in the creation of a rule based fuzzy system:

1. Identification of the inputs and their ranges and naming them.

2. Identification of the outputs and their ranges and naming them.

3. Creation of the degree of fuzzy membership functions for each input and output.

4. Construction of the rule base that the system will operate under

5. Decision on how the action will be executed by assigning strengths to the rules

6. Combination of the rules and defuzzification of the output.

Fuzzy systems operate by testing variables with IFTHEN rules, which produce appropriate responses. A wide variety of shapes is possible fulfilment functions, with triangles and trapezoids being the most popular. Membership functions for this study were of the form:

$$\mu\ (Vp,Fp,\ Op,Wp,Tp,Ip) = \exp\ (-(|Vp-Fp-Op-Wp-Ip|)/Tp)^{Ip}\ ) \quad (1)$$

Where Vp = Phase voltage Parameter, Fp = Fuel Parameter, Op = Oil Parameter, Wp = Water Parameter, Tp = Temperature, Parameter, Ip = index parameter. In this work, Vp, Fp, Op, Wp, Tp, Ip are the ICOFLS chosen parameters whose values are tested and hence used to generate the surface diagrams in this work. The functions were chosen because of their flexibility, by varying Vp, Fp, Op, Wp, Tp and Ip, the whole families of different functions were obtained for μ (Vp, Fp, Op, Wp, Tp, Ip).

Figure 5 shows the flow model of the three phase line and the generator.

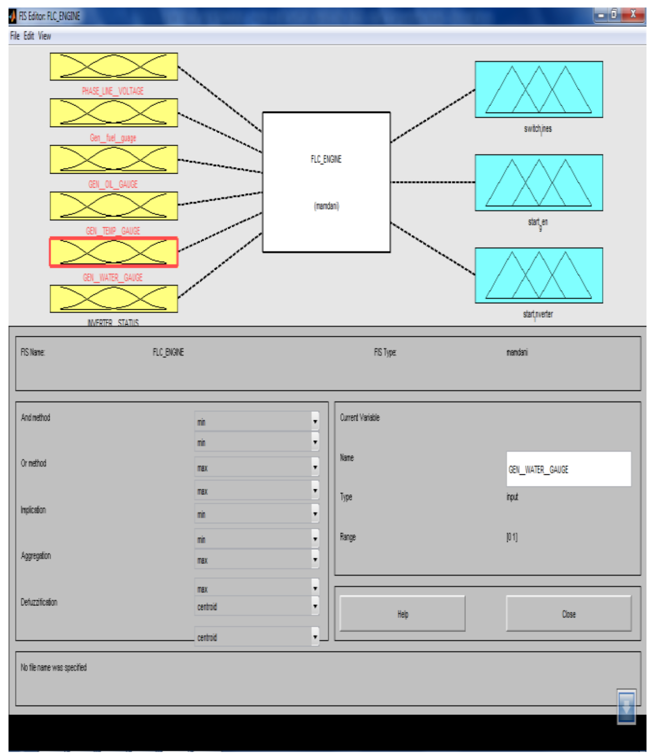

Fig. 5: FIS Editor Model of ICOFLS with FLC Engine

V. RESULTS AND ANALYSIS

Figure 6.1-6.8: shows the MATLAB fuzzy plots of the system under analysis. In this work, the MATLAB rule viewer and surface viewer was used for the result analysis. The Rule Viewer is a MATLAB based display of the fuzzy inference diagram shown in this work. As a diagnostic, it shows which rules are active and how individual membership function shapes are influencing the results. The Surface Viewer is used to display the dependency of one of the outputs on any one or two of the inputs—that is, it generates and plots an output surface map for the system.

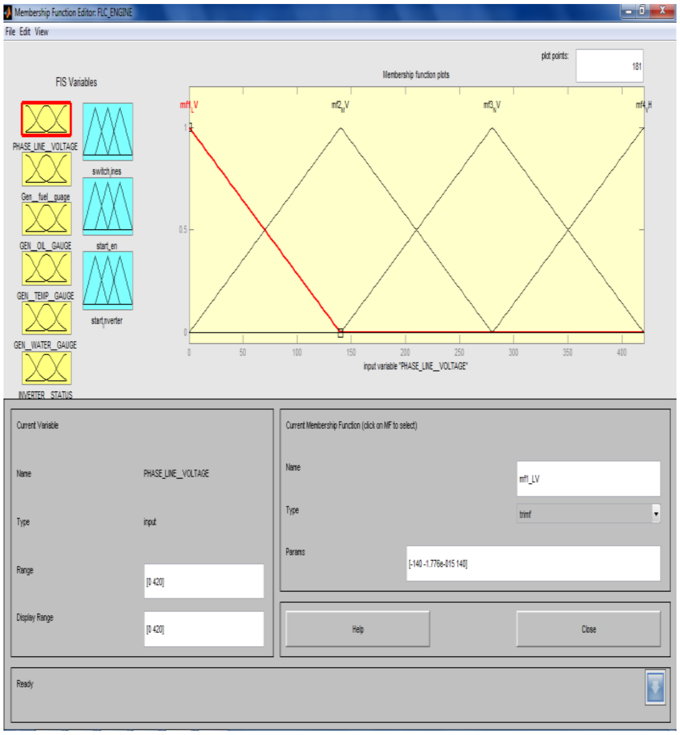

Fig. 6.1: Membership function of ICOFLS with FIS variable

Figure 6.1 & 3.3i shows the membership functions for the ICOFLS in this work for MATLAB and Proteus ISIS. For the phase voltage, the plot shows the low voltage state (Mf_Lv), Medium voltage state (Mf_Mv), Normal voltage state (Mf_Nv), High voltage state (Mf_Hv) with a fuzzy range [0 420]. The Fuzzy inference engine uses the rule base to generate appropriate responses to be defuzzified and passed on to the output dashboard. Also, the membership functions of other process variables (fuel gauge, gen_oil, water_gauge, inverter status) were defined and represented in the rule base.

Figure 6.2 shows the rule base descriptions for the mamdani FIS for the ICOFLS. The idea behind fuzzy inference is to interpret the values in the input and based on some of rules in the rule editor, assigns values to the output vector. From figure 6.2 GEN_WATER_GAUGEand INVERTER_STATUS forms the antecedent in this context while START_GEN and START_INVERTER are the derived consequents. For each rule, the inference engine looks up the membership values according to the condition of the rule. The resulting fuzzy set must be converted to a number that can be sent to the process as a control signal (crisp control signal). The fuzzification block converts each piece of input data to degrees of membership by a lookup in one or several membership functions. Thus, it matches the input data with the conditions of the rules to determine how well the condition of each rule matches that particular input instance.

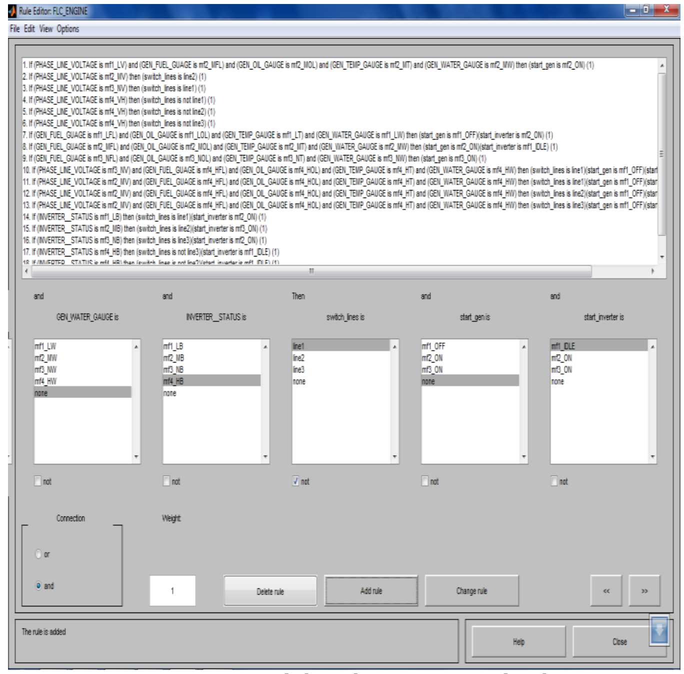

Fig. 6.2: ICOFLS Rule base descriptions in Rule Editor

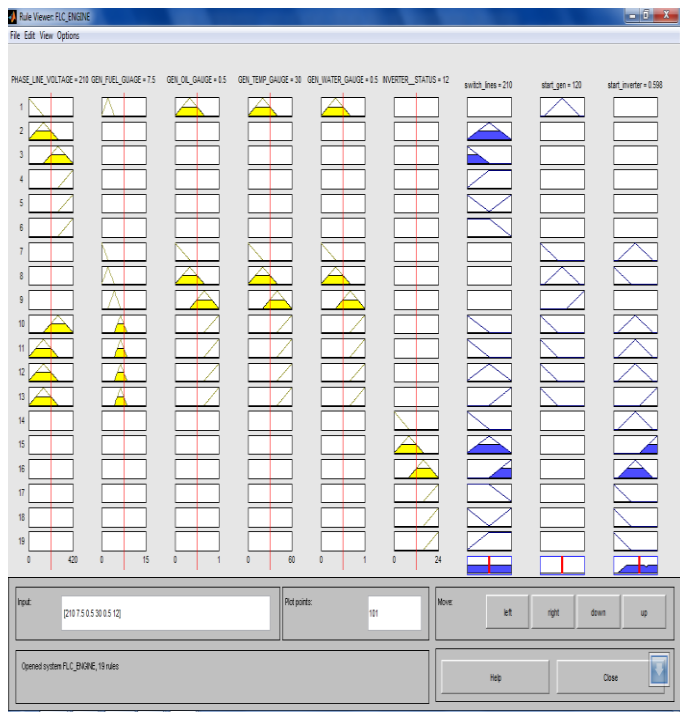

Fig. 6.3: ICOFLS Rule viewer Results for the process and Control variables

Figure 6.3 shows the rule view plots. The Rule Viewer displays the roadmap of the whole fuzzy inference process. It is based on the fuzzy inference diagram described in the previous section. The Rule Viewer shows one calculation at a time and in great detail. In this sense, it presents a sort of micro view of the fuzzy inference system. Figure 6.3 shows a figure window with 19 plots nested in it. The nine plots across the top of the figure represent the antecedent and consequent of the entire rule base of the ICOFLS.

Each rule is a row of plots, and each column is a variable. The rule numbers are displayed on the left of each row. The columns of plots (6) show the membership functions referenced by the antecedent, or the if-part of each rule while the column of plots (the 3 blue plots) shows the membership functions referenced by the consequent, or the then-part of each rule. The Rule Viewer allows for interpretation of the entire fuzzy inference process at once and also shows how the shape of certain membership functions influences the overall result. Because it plots every part of every rule, it can become unwieldy for particularly large systems, but, for a relatively small number of inputs and outputs, it performs well (depending on how much screen space devoted to it) with up to 30 rules and as many as 6 or 7 variables.

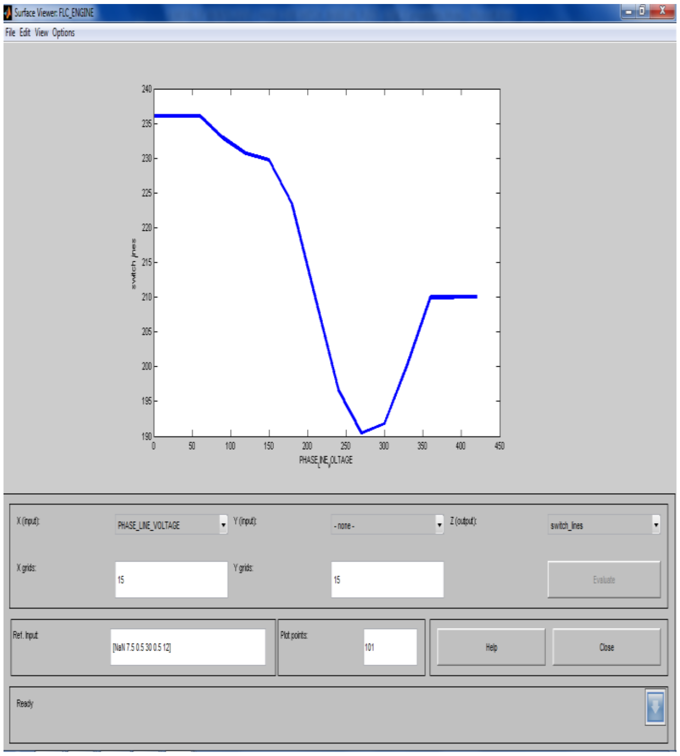

Fig. 6.4: ICOFLS surface viewer plot for the phase voltage against switch lines control variable.

Figure 6.4 shows a surface view plot for the phase voltage against the switched lines. It allows the entire span of the output set based on the entire span of the input set. The phase line mapping [0 420] with the corresponding switched lines are tagged values; lines 1, line2 and line3 are tagged values of [0 240]. The phase selector is based on the input voltage state and its presence. The switch_line coordinate (Y) with a range of 0 to 240 fuzzy switching states detects the valid phase_voltage membership states. From the plot, the target valid phase voltages are between 200 and 300 volts corresponding to the switch line states [0 205]. Outside these ranges, the ICOFLS bypasses the load switching. Hence, when all other conditions of the rule engine are not meet and either the phase lines satisfy the rule base, the switch_line routine manages the load satisfactorily.

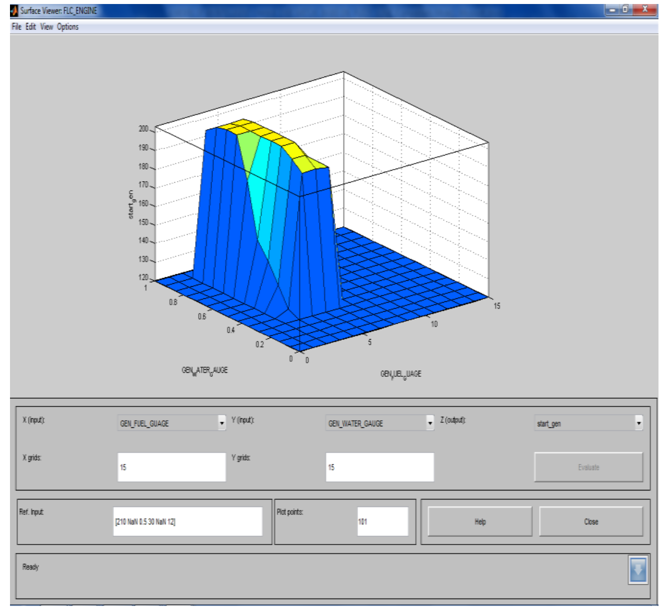

Fig. 6.5: ICOFLS surface viewer plots for the process variables against start_gen control variable.

From figure 6.5, the dependency relations for start_gen control process is between generator fuel gauge and water gauge assuming an outage in the phase lines. From the plot, surfaces in figure 6.5 show the functions approximated by the corresponding rule base. These result allow the start_gen routine to compare between the generator fuel gauge and water gauge and then powers up the terminal loads assuming a state failure in the phase lines. In this context, the start_gen stability state is at point 200 on the Y-axis of the surface diagram. At startup phase, the inverter system starts its charging operations as specified in the algorithm.

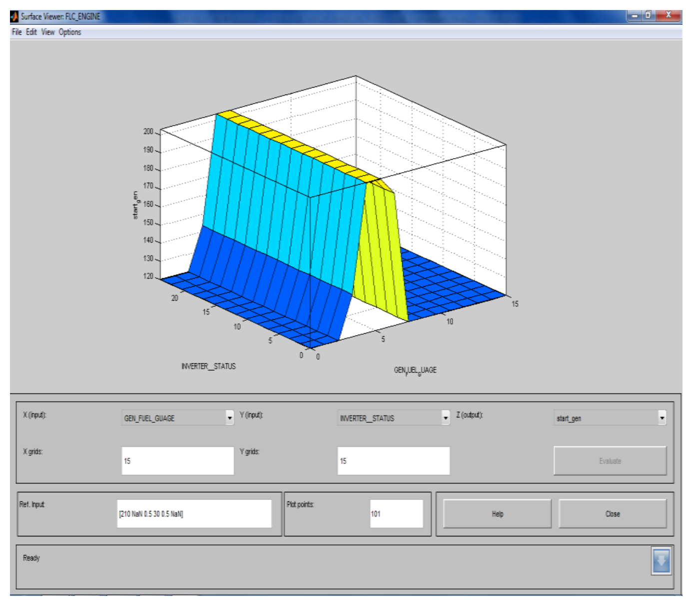

Fig. 6.6: ICOFLS surface viewer Results for the process fuel gauge, inverter status and Control variable start-gen.

In figure 6.6, the operating condition of the system is quasi-static as the required conditions for the generator initialization is not satisfied and there is phase or line presence. For the start_gen routine to execute and start the generator, all parameters of the generator must be present and verified before the switching; else the inverter system drives the load even at the start_gen state of 150. This state will rarely occur because the generator parameters will always be present at all instances.

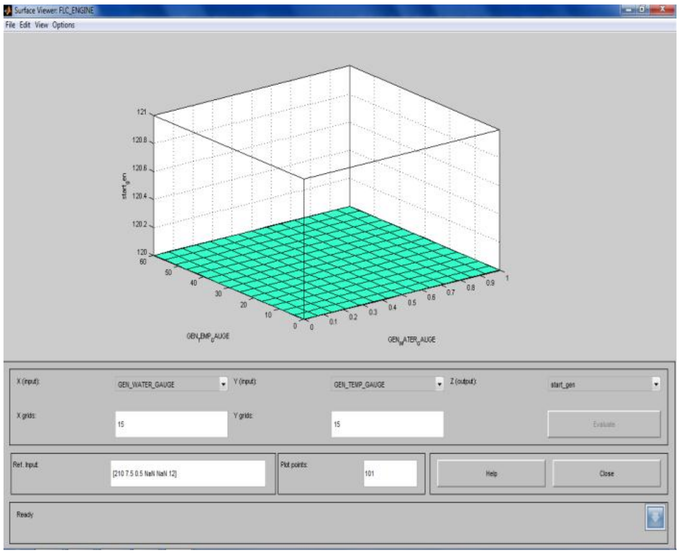

Fig. 6.7: ICOFLS surface viewer plots for the process water gauge, temp gauge and Control variable start gen.

The plot in figure 6.7 is a ground state for the ICOFLS. The generator fuel gauge and temperature specifications in the surface diagram flags an error and as such remain in the idle state. A case of no phase voltage will demand load switching from the generator or the inverter on full charge, but an improper parameter level for generator will ground the system. As such this condition must be avoided to ensure continuous supply to the load system.

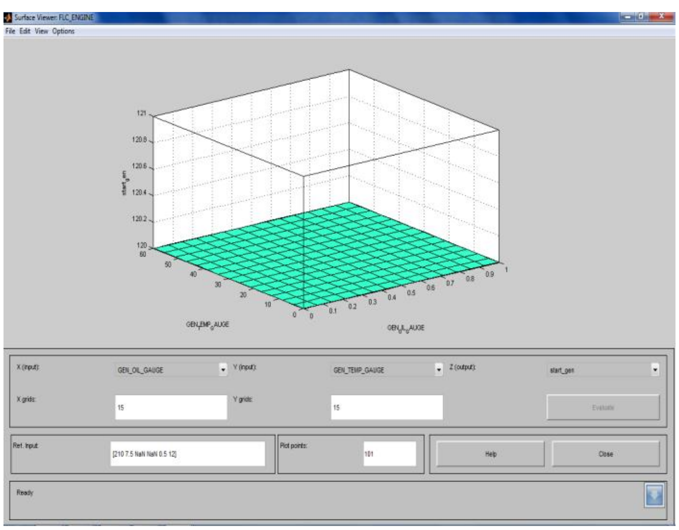

Fig. 6.8: ICOFLS surface viewer plots for the process variable (oil gauge, temp gauge) and Control variable: start gen

Also, figure 6.8 presents a ground state for the system explanation in figure 6.7. The start_gen routine only recognizes a proper parameter specification in generator system to power up the load chains.

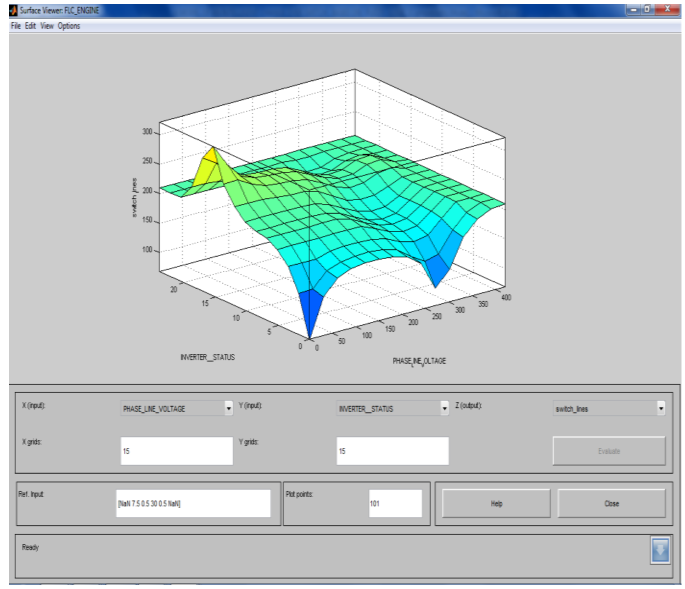

Fig. 6.9: ICOFLS surface viewer plots for the process variable (Inverter Status, phase voltage) control variable (switch lines).

Figure 6.9 shows an optimized state for the loads. The presence of the phase voltage deactivates the generator system while switching the loads and the inverter system. The line states (membership values) of 0 to 300 volts are acceptable for our case and can power on the loads with no risk. The presence of a high voltage state [300-400] is abruptly ignored by the system. The rule and inference engine carries out this process control. As such, this regulation process can reliably safeguard domestic load systems or equipments. In this case also, the inverter system still charges its battery to maximum regulation charge. This is a desirable mode in the ICOFLS model.

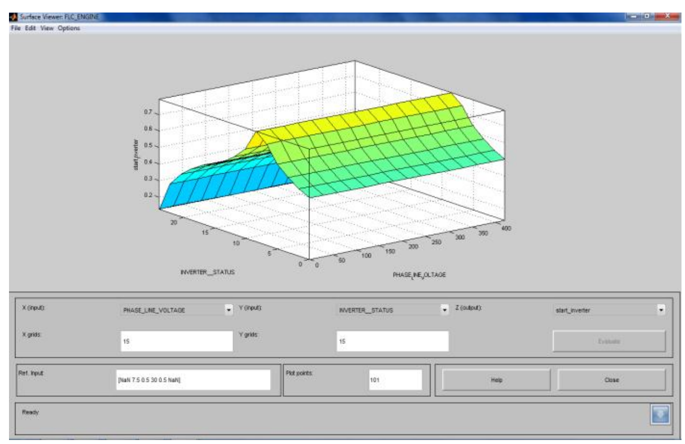

Fig. 6.10: ICOFLS surface viewer plots for the process variable (Inverter Status, phase voltage) and control variable start inverter.

A regulation process from an abrupt transition is depicted in figure 6.10. This is from the line to the inverter system.

Usually, a sudden phase outage causes the start_inverter routine to fully power the loads from the inverter system. In this case, the phase voltage possibility ranges from 0 to 400 and 0 to 20 for the inverter system. The pattern explains a continuous supply to the loads at the instance of outage while neglecting the generator system and its parameters.

In all cases, the goal of ICOFLS model is to provide a system based on approximate reasoning that produces an estimate probability of switching success for the considered entities in this work. This will be based on critical evaluation of the specified criteria in the rule base of the ICOFLS.

VI. Discussions

The design of the proposed ICOFLS is based on the fundamental concept of changing over from one power source to another based on fuzzy logic controller approach. Certain requirements such as automatic control, easy acquisition of data, simple architecture and design to make the technique as self-determining as possible was taken into consideration while making the design. All these were transformed into the system architecture and functional modeling with MATLAB fuzzy blockset and simulation with Proteus ISIS depicting the operation and control scheme of the developed ICOFLS. The system references the rule base and the inference engine to execute the switching controls of the phase lines, generator and inverter system. The architecture of the system is presented, while generating the graphical plots of the process and control variables.

From the different validation exercise, the units attributes of the system such as collecting input signal from the sensors (Oil, fuel and water sensors), processing output, carrying out complex digital signal processing display status of the parameters and the power source has been established in the system model. This system will contribute to solving some of the power problems in Nigeria and creating least administrative efforts with little system overhead at large.

VII. Future Scopes Of The Experiment

MATLAB/SIMULINK is used to simulate and fine-tune the controller model, but future work will investigate on stability analysis of the model with respect to the performance metrics such as overshoot, rise time, settling time and steady state error. Again, FPGA chip will be used for gate level implementation with the corresponding finite state machines. Relevant mathematical models will be presented for the ICOFLS design in this regard.

VIII. Conclusions

A hybrid fuzzy controller structure called the ICOFLS is modeled for the development of the knowledge based fuzzy controllers for load-power switching and control in this work. The development structure is especially for real time applications of fuzzy logic theory. This work has presented an ICOFLS that aims effectively control load switching using a rule based engine. The graphical plots show the reliability and its optimal performance with very low latency offered by the ICOFLS. By focusing on this approach, the knowledge and capabilities acquired can readily be transferred and applied to more complex projects since some of the already existing ones lack intelligence and users are looking forward to a smarter system. Unlike the manual and automatic changeover switch that have been in existence with their constraints ranging from the manpower to switch on and off, the time delay during which serious losses and even life is encountered, starting the generator without running the necessary checks and many other constraints. Hence this research has presented a system that can switch and make efficient monitoring using Mamdani fuzzy logic approach.

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Introduction of the weight edition errors in the Levenshtein distance

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***Abstract*— In this paper, we present a new approach dedicated to correcting the spelling errors of the Arabic language. This approach corrects typographical errors like inserting, deleting, and permutation. Our method is inspired from the Levenshtein algorithm, and allows a finer and better scheduling than Levenshtein. The results obtained are very satisfactory and encouraging, which shows the interest of our new approach.**

Keywords- component;spelling errors; correction; Levenshtein distance; weight edition error.

I. INTRODUCTION

Automatic correction of spelling errors is one of the most important areas of natural language processing. Research in this area started in the 60s [1]. Spell checking is to find the word closest to the erroneous word and words in the lexicon. This approach is based on the similarity and the distance between words.

In the areas we are interested in the treatment of misspelling out of context; several studies have been achieved to present methods of automatic corrections. Among these works, we cite:

- The first studies have been devoted to determining the different type of elementary spelling error, called editing operations [2] which are:
  - Insertion: add a character.
  - Deletion: omission of a character.
  - Permutation: change of position between characters.
  - Replacement: replace a character with another.
- Based on the work of Damerau, Levenshtein [3] considered only three editing operations (insertion, deletion, permutation) and defined his method as edit distance. This distance compares two words by calculating the number of editing operations that transforms the wrong word to the correct word. This distance is called Damerau-Levenshtein distance.
- Oflazer [4] proposed a new approach called “Error tolerant Recognition”, based on the use of a dictionary represented as finite state automata. According to this approach, the correction of an erroneous word is to browse an automata-dictionary for each transition by calculating a distance called cut-off edit distance, and stack all the transitions not exceeding a maximum threshold of errors. Savary [5] proposed a variant of this method by excluding the use of cut-off edit distance.
- Pollock and Zamora [6] have defined another way to represent a spelling error by calculating the so called alpha-code (skeleton Key), hence the need for two dictionaries: a dictionary of words and other for alpha-codes. Therefore, to correct an erroneous word, we extract its alpha-code and comparing it to the alpha codes closest. This method is effective in the case of permutation errors. Ndiaye and Faltin [7] proposed an alternative method of alpha code, who defined a system of suitable spelling correction for learning the French language, based on the method of alpha code modified by combining other techniques such as phonetic reinterpretation, in case where the first method does not find solutions.
- A critical analysis of existing systems for spell checker, realized by Souque [8] and Mitton [9], confirms that these systems have limitations in the proposed solutions to some type of erroneous word.

In the work presented in this paper, we propose a new metric approach inspired from the Levenshtein algorithm. This approach associates for each comparison between two words a weight, which is a decimal number and not an integer. This weight allows the better and perfect scheduling solutions proposed by the correcting system of the spelling errors.

II. LEVENSHTEIN ALGORITHM

The metric method developed by Levenshtein [3], measures the minimal number of elementary editing operations to transform one word to another. The minimum term was defined by Wagner and Fischer [1] thus proposing the programming dynamic technique to solve the edit distance. Elementary editing operations considered by Levenshtein are:

- Insertion: Add a character 'ش' (مدرسشة)
- Deletion: omission of the character 'ر' (مدسة)
- Permutation: replacement of the character 'ر' with a 'س' (مدسرة)

The calculation procedure of the Levenshtein distance between two strings $X = x_1x_2...x_m$ of length m and

$Y = y_1y_2...y_n$ of lengthn, consists in calculating recursively the edit distance between different substrings of X and Y.

The edit distance between the substrings $X_1^i = x_1x_2...x_i$ and $Y_1^j = y_1\ y_2...y_j$ is given by the following recursive relationship:

$$D(i,j) = D(X_1^i, Y_1^j)$$
$$D(i,j) = min\{ D(i-1,j)+1, D(i,j-1)+1, D(i-1,j-1)+cost \}$$

With $cost = \begin{cases} 0 & if\ x_{i-1} = y_{j-1} \\ 1 & else \end{cases}$

and the following initializations: D(i,∅)=i and D(∅,j)=j, where ∅ represents the empty string.

Example:

TABLE I. CALCULATION OF EDIT DISTANCE

		م	د	ر	س	ة
	0	1	2	3	4	5
م	1	0	1	2	3	4
د	2	1	0	1	2	3
س	3	2	1	1	1	2
ر	4	3	2	1	2	2
ة	5	4	3	2	2	2

The matrix shows the recursive calculation of the Levenshtein distance between the erroneous word "مدسرة" and the dictionary word "مدرسة", the distance is 2.

The limitation of such a spelling correction system using the edit distance is not to allow a correct order of suggested solutions to a set of candidates having the same edit distance.

For example, we have the dictionary word "السيف" and the erroneous word "السيق", the Levenshtein method returns the same edit distance for the following set of words.

Erroneous word	Dictionary words	Edit distance
السيق	الساق	1
	السوق	1
	السبق	1
	السيف	1
	السين	1
	الشيق	1

In order to remedy to this limitation, we propose an adaptation of the Levenshtein distance. This adaptation gives a better scheduling of the solutions having the same edit distance.

III. LEVENSHTEIN METHOD ADJUSTED

To remedy to the scheduling problem, we introduced the frequency of the three type errors of the editing operations.

We carried a test with four experienced users: they have typed a set of Arabic documents in order to calculate the frequency error of the editing operations. For this, we define the following three matrices:

- Matrix frequency of insertion error.
- Matrix frequency of deletion error.
- Matrix frequency of permutation error.

In this context, we modified the Levenshtein distance between two words by taking into account these three matrices.

More formally, for two strings $X = x_1x_2x_{3..}x_m$ of length m and $Y = y_1\ y_2\ y_3..y_n$ of lengthn, the calculation procedure of the measurement between X and Y is done in the same manner as that of Levenshtein algorithm, but introducing the matrices frequency of the editing errors. This measure $\mathcal{M}$(i,j) is given by the recursive relationship :

$$\mathcal{M}(i,j) = min\{\mathcal{M}(i-1,j)+1-\mathcal{F}_{aj}(x_{i-1}), \mathcal{M}(i,j-1)+1-\mathcal{F}_{sup}(y_{j-1}), \mathcal{M}(i-1,j-1)+cost\}$$

With $cost = \begin{cases} 0\ if x_{i-1} = y_{j-1} \\ 1-\mathcal{F}_{permut}(x_{i-1}/y_{j-1})\ else \end{cases}$

And

- $\mathcal{F}_{aj}(x_i)$ = the error frequency of adding the character 'x_i' in a word.
- $\mathcal{F}_{sup}(y_j)$ = the error frequency of deleting the character 'y_j' in a word.
- $\mathcal{F}_{permut}(x_i / y_j)$ = the error frequency of the permutation 'x_i' with the character 'y_j'.

For the algorithm, we take the following initializations:

- $\mathcal{M}(0,0)=0$
- $\mathcal{M}(i,0)=\mathcal{M}(i-1,0)+\mathcal{F}_{aj}(x_{i-1})$
- $\mathcal{M}(0,j)=\mathcal{M}(0,j-1)+\mathcal{F}_{sup}(y_{j-1})$

Example:

The measure between two words "السيق" and "السيف" is calculated in the following matrix:

		ا	ل	س	ي	ف
	0	0,1785	0,2525	0,2525	0,3771	0,3771
ا	0,1111	0	0,9259	1,1414	1,2525	1,2660
ل	0,2657	0,8454	0	1,0000	1,8754	2,1114
س	0,2802	1,1017	0,9855	0	0,8754	1,8754
ي	0,4058	1,2273	1,8599	0,8744	0	1,0000
ق	0,4058	1,2273	2,1533	1,8744	1,0000	0,9911

The measure $\mathcal{M}$ (السيق, السيف) = 0,9911.

IV. Tests and results

The statistical study that we have done is to determine the frequency of errors editing operations (insertion, deletion, permutation). For this, we launched a typing test of Arabic documents for a set of users.

Our training corpus is a set of Arabic documents typed by four expert users. From this corpus, we calculated the three matrices of error previously defined.

TABLE II. STATISTIC ON EDITING ERROR

Editing operation	Number of errors	Total
Insertion	202	1420
Deletion	295	
Permutation	923	

To test our method, we have performed a comparison between our approach and that of Levenshtein for scheduling of the solutions. The implementation of our approach was performed by a developed program in Java language.

To compare our approach with that Levenshtein, we processed only 190 errors. The results obtained are summarized such as:

- Of 190 erroneous words, our method correctly classified 119 words in the first position, while the Levenshtein distance has only 19 classified in the first position. The rest of 119 was distributed on the 2nd, 3rd, 4th, 5th... 10th position. Statistically our method has proposed 62.63% of correct words in the first position against 10% for the Levenshtein.
- Of 71 erroneous words, our method has ranked in second position 40 solutions, while for these 40 erroneous words Levenshtein distance was only 15 classified in 2nd position and the remaining 25 were distributed on the 3rd, 4th, 5th, ..., 10th position with a rate of 21.05% against 7.89% for the Levenshtein.
- Of 30 erroneous words, our method proposed 21 corrections in the third position, while on these 21 words Levenshtein method proposed that 5 in 3rd position and the rest distributed over the posterior positions, giving a rate of 11.05% for our method and 2.63% for the Levenshtein distance.
- For the remaining 10 erroneous words, our method has positioned in the fourth positions whereas the edit distance has proposed the following: 3 in 4th, 3 in 5th, 2 in 8th and 2 in 10th with a rate of 5.26% for our method and 1.57% for the Levenshtein. The table below summarizes the results obtained.

TABLE III. PERCCENTAGE OF SCHEDULING SOLUTIONS

	First position	Second position	Third position	Fourth position
Lev. Meth. Adjusted	62,63%	21,05%	11,05%	5,26%
Levenshtein	10%	8%	2,63%	1,57%

V. Conclusion

In conclusion, we note the interest of our method in scheduling of correct words for the first and second positions while for the third and fourth positions can justify this by the unavailability of frequencies (zero frequency) for some Arabic alphabetic character during execution of our test.

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