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DESIGN OPTIMIZATION OF INDUSTRIAL WIRELESS NETWORK USING GENETIC ALGORITHMS

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Abstract:

Transferring information over long distance using wireless communication has become a topic of great interest in our days and is widely used in all areas, from educational to military or from medical to industrial. The quality of information is influenced by several factors and they differ according to the environment of the domain of interests.

In this paper will be shows how to optimize the design of an industrial wireless network using genetic algorithms theory. In this case, the authors discuss about a wireless system sensor located into an industrial furnaces used for monitoring and controlling of temperature and transmitting data to a server through an access point. Using genetic algorithms we want to find the optimal way for placement of access point so that data is transmitted without any problems occur. Is desirable for us to find, using genetic algorithms, and the best place for any equipment so the effect of interferences to be minimal. Interferences that can affect the quality of information transmitted through wireless communication can be internal noise (the equipment itself) and also external noise and other fields. The authors are using genetic algorithms in solving the main problems caused by external noise on the signal.

The advantage of using genetic algorithms in this kind of application, for optimizations of parameters, refers to the fact that they are modular, they are good for noisy environment, and there is always solution that gets better with time.

Mathematics Subject Classifications 2010: *11Y16, 68Q25, 68T01.*
Keywords: *genetic algorithms, indoor radio communication, optimization, wireless sensor network.*

1. INTRODUCTION

In this paper is presented an optimization problem, using genetic algorithms, regarding the distance in wireless communications network so that the path loss to be minimal. This way we want to identify the maximum distance that can be fixed between an access point and a wireless sensor installed on industrial equipment so that data transmitted to the server to reach the optimal conditions.

In this case, the parameters are encoded by the genetic algorithm problem in a number of "chromosomes". In practice the usual case of several parameters, the string contains multiple substrings called "gene". Each chromosome represents one possible solution proposed to solve the problem.

Genetic algorithms perform specific operations on functions within the criteria of a reproduction process governed by the following genetic operators: selection, crossing and mutation to optimize.

In this way, starting from a random population of chromosomes, each new population generated by reproduction and function replaces the previous generation, moving towards optimum criterion, it also provides solutions to the problem originating in getting better.

For a better understanding of how this genetic algorithms used for optimization are working and which is the order of processes we can look to next figure.

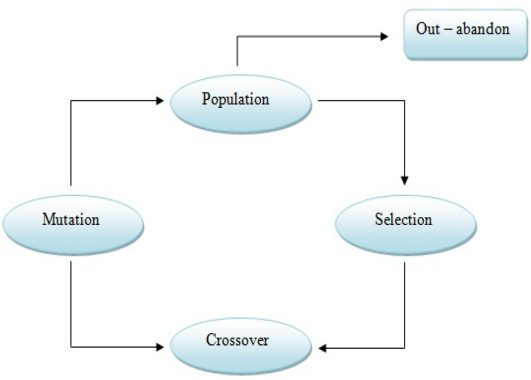

Fig. 1. Genetic algorithm cycle

These steps will repeat until we can see that the population there is a new format that highlights the chromosome. For a chromosome to be considered the dominant one the winner of the cycle, its representability should be greater than 70%, the best value is around 95%.

2. GENETIC ALGORITHM IMPLEMENTATION

As it was said before, the problem of optimization refers to the distance between two points. Those two points represents the industrial equipment, industrial furnace, and a router which helps us communicate to the end user. It also should be mentioned that the industrial furnace has a wireless sensor that measure the temperature and can send data to the server; such a design can be observed below.

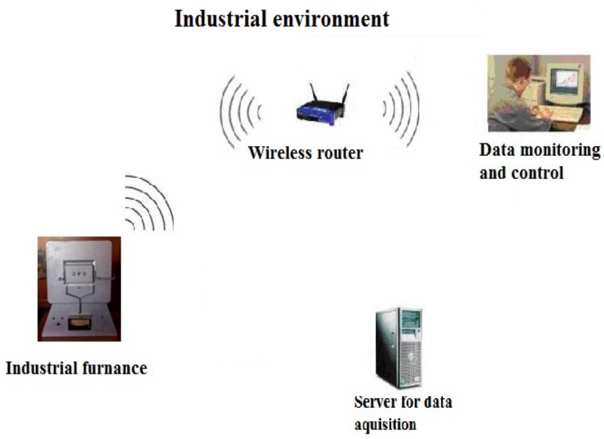

Fig. 2. Design of the industrial network

The reason that the authors of this paper decided to develop this algorithm for optimization of distance represents the interferences that are in industrial environment. It is desirable that the path loss to be minimal and the distance to be maxim. The function that represents this hypothesis is:

$$P_L = \frac{\lambda^2}{(4\pi)^2 d^2} \qquad (1)$$

where P_L – represents the path loss in indoor data transfer, λ – represents broadband and d – is the distance that we want to optimize.

To implement the genetic algorithm to explain the way that solve our function we chose a population of 8 chromosomes that will be represented in 4-bit of data.

The first steps, after representing the chromosomes, the value of the function should be calculated, we have this value in table 1

Tabel 1.

Simbol	String	Value	Function $F(S_i)$
S_1	0001	1	63,3900
S_2	0010	2	31,6950
S_3	0100	4	15,8475
S_4	0110	6	10,5650
S_5	1000	8	7,9237
S_6	1010	10	6,3390
S_7	1100	12	5,2825
S_8	1110	14	4,5279

After this, we have to determine the probability of selection (p_i) and also the cumulative probability (C_{pj}). The formulas for this are:

$$p_i = \frac{F(S_i)}{\sum_1^8 F(S_i)} \quad (2)$$

$$C_{pj} = C_{pj-1} + p_j \quad (3)$$

For making this calculation the sum value is needed, and this is 145,5706. And also for making the selection we need to generate 8 random numbers, in the interval [0, 1]. For this a LabVIEW program was done, so that the numbers to be generated automatically, and to ensure uniform coverage of the interval and variety. All the calculated values till now are in table 2.

Tabel 2.

	p_i	C_{pj}	Random number
C_1	0,435459	0,435459	0,5375
C_2	0,217729	0,653188	0,3628
C_3	0,108865	0,762053	0,7981
C_4	0,072576	0,834629	0,5728
C_5	0,054432	0,889062	0,4831
C_6	0,043546	0,932608	0,8136
C_7	0,036288	0,968896	0,9975
C_8	0,031104	1	0,4502

Now we will compare the value for C_{pj} with the random numbers (tabel 3) and after that we gone have a new list of chromosomes. The new list is presented in tabel 4 also with the relation between the new chromosomes and the initial value. Those chromosomes are going to poarticipate to the next process, crossover.

Tabel 3

C2=0,3627	< 0,4355 >	C8=0,4502	C'$_1$
C4=0,5727	< 0,6532 >	C3=0,7980	C'$_2$
C4=0,5727	< 0,7621 >	C3=0,7980	C'$_3$
C6=0,8135	< 0,8346 >	C7=0,9975	C'$_4$
C6=0,8135	< 0,8891 >	C7=0,9975	C'$_5$
C6=0,8135	< 0,9326 >	C7=0,9975	C'$_6$
C6=0,8135	< 0,9689 >	C7=0,9975	C'$_7$
C7=0,9975	< 1,0000 >		C'$_8$

As is shown in the table before C_1 and C_7 appear ones, C_4 two times and the dominant is C_6 with four representations. So, this way is visible that we start to have some strong representant.

The dominant accents appear each step, but things can change any moment because of the diversity of the model.

Tabel 4.

C'$_1$	C2	**0,0467**
C'$_2$	C4	**0,1859**
C'$_3$	C4	0,4062
C'$_4$	C6	0,4216
C'$_5$	C6	**0,2436**
C'$_6$	C6	0,3761
C'$_7$	C6	0,4812
C'$_8$	C7	**0,1804**

The condition that those chromosomes should satisfies is that their probability to be smaller than the probability of the process, p_c=0,25. Those probabilities are going to be generated randomly, as the ones before. This step is also shown in table 4, the bold numbers are the value for the chromosomes that are going to participate to crossover.

For this operation we are going to have two pairs of chromosomes, C'$_1$ and C'$_2$ the first one and C'$_5$ and C'$_8$ the second. For each pair we need a number for the bit where the cross is goin to take place. So for the firs pair the crossover point was 2 and for the second was 3 the modification is going to be illustrated in figure 3.

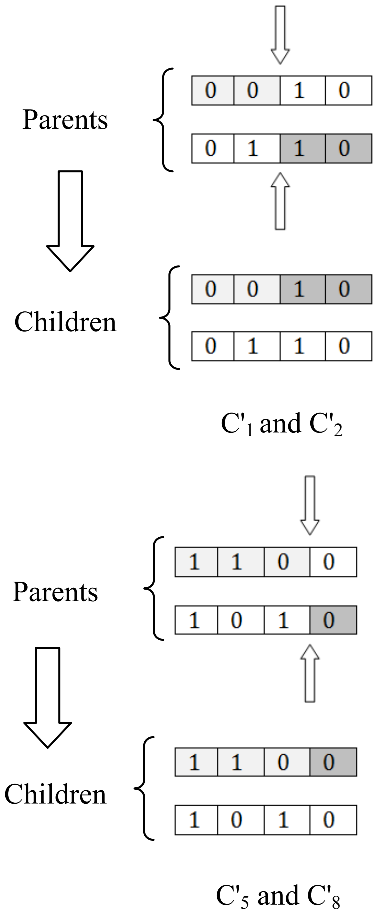

Fig. 3. Crossover process

Finishing this we have the new chromosomes that are going to go to the next level. We can see that we have somehow a dominant chromosome C$_6$, but we have to see what happened next.

In table 5 we have the new list of chromosomes, and the probability of selection calculated for current values. The number colored in red, represents the chromosomes that fulfill the condition for mutation. This means that their probability is smaller then the process probability, p_m=0,06.

Tabel 5.

C4	10,5650	0,111111
C2	31,6950	0,333333
C4	10,5650	0,111111
C6	10,5650	0,111111
C7	5,2825	**0,055556**
C6	10,5650	0,111111
C6	10,5650	0,111111
C7	5,2825	**0,055556**

Chromosome C$_7$ is going to participate to the mutation process. Is the only one that has the probability smaller then p_m.

For finishing this process we should know the number of the bit position for mutation. This number is going to be generated also randomly, and is 2 so the second bit is going to change. The scheme for this is illustrate in figure 4.

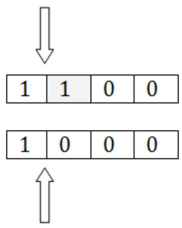

Fig. 4. Mutation process

Because after one cycle no chromosome is dominant the procedure should be repeated. The percentage of C$_6$ the most representative is only 60% that is not good enough.

After performing one more time the new result determine that C$_7$ is the most dominant chromosome, the percentage being 87,5. This is a representative value having the fact that the population that we discussed about is not to large.

After making the same two chromosome cycles as the one descried before, starting with a population of 50 chromosomes of 7 bits of data each, it can really see a dominant, its share being 75%. Chromosome that correspond to the value of 74 meters of distance. This value is good considering that the maximum is 98 meters.

To verify the results, the calculations were redone for the same population only the random numbers that have influenced evolution were changed, using the same program. After conducting 10 different experiments could be observed that the distance is approximately the same for several cases or around the same values. So the best distance that produced lest loss is around 74 – 78 meters.

To ensure the accuracy of the information obtained we went to solve the algorithm through programming languages. Given that the most popular programming language that is used to solve genetic algorithms is Matlab, I went to developing such a program. For the beginning the program created can analyzes only six chromosomes, each having three bits. In this way is desired to see if the accuracy of the assessment process is ensured, but also the evolution of the results.

3. FUTURE WORK

The first thing that the authors of this paper want to develop is an automat program that can be used to solve this kind of algorithm.

As soon as possible the complete form of the model will be test in Matlab. This representing the whole population of 50 chromosomes that correspond to distances considered of interest. And also we have the idea to try to develop a program that can read the chromosomes from another sheet, a list of predefined values. This way is going to be much easier to modify the characteristics of any kind of population.

Also the genetic algorithm model is going to be test using the graphical programming environment LabVIEW.

After verifying the model through this two programming languages there is any doubt about its accuracy. This way we can say that the optimal value that we have is the best in this case.

4. CONCLUSIONS

Genetic algorithms represent a simplistic way that some parameters can be optimized and is also a way that each time gives a better value for the problem that you want to solve using them.

Optimization of mathematical functions that can describe various physical quantities, using genetic algorithms leads to more efficient systems. The achievement of equipment that can work at full capacity is one of the most important criteria that are used by clients for the analysis of a product in our current market conditions.

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