A Study of the Accuracy of Positioning in a Network of Wireless Underwater Sensors Depending on the Genetic Algorithm

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Abstract

Wireless Sensors Networks (WSNs) are a scientific revolution in wireless communications and embedded systems. WSN is based on the idea of abandoning the human factor, which was often an obstacle because it was not possible to be in the places where these networks are placed, especially if the collection of information required a long time, Underwater wireless sensor nodes can be deployed for monitoring, exploration, and for disaster protection, and this is what is called Underwater Wireless Sensor Networks (UWSNs). nIn this paper, we will study how the parameters of the genetic algorithm change when locating sensors under water, Including the error rate, the number of nodes in the network and the time taken to implement.

Keywords: wirelss, Sensor; Genetic algorithm; positioning of a network

1. Introduction

Underwater wireless sensor networks offer many applications such as pollution monitoring, disaster avoidance, assistance in maritime navigation and other important applications in human life. These networks have also replaced humans in exploring the depths of the seas and oceans, which are unsafe in addition to the difficulty of navigating and staying for a long time. Therefore, large, expensive and individual traditional ocean monitoring devices have been replaced by small underwater sensors capable of communicating with each other through audio signals, as radio frequencies do not propagate well in an underwater environment, so we use audio channels.

The positioning of underwater sensor nodes is one of the most important technologies because it plays an important role in many applications, and this is due to the benefit gained from knowing the locations of nodes in facilitating the work of the network in general, as the importance of Node location information comes from the ease that this information provides in network routing and Control [3], in other words, "the occurrence of the phenomenon without knowing its location is less important or sometimes meaningless".

This research is aimed at studying the change of parameters in underwater wireless sensor networks after determining the locations of nodes in the network using the genetic algorithm [11].
In this research, we tested the accuracy of the genetic algorithm when locating nodes deployed in underwater wireless sensor networks using a number of anchor nodes. There are many simulation programs working with wireless sensor networks, such as NS2, OMNET++ and others, but an algorithm based on calculations was chosen, so Matrix Laboratory (MATLAB) was used, which is based on a high-level programming language and provides an integrated environment of digital calculation and graphics, which made it the most suitable in this research [11].

Types of nodes in underwater wireless sensor networks

Underwater wireless sensor networks consist mainly of four types of nodes [12] as in Figure (1):

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floating nodes: they are nodes installed on the surface of the water, equipped with G GPS, play important roles in navigation and guidance.
separate ascending transmitter/ receiver nodes: these nodes mainly consist of an elevator and audio transceivers. The elevator helps the node to rise or dive vertically into the water, the transceiver communicates with the anchor nodes at different depths.
anchor nodes: its primary role is to assist in locating the nodes of ordinary sensors.
standard sensor nodes: their main task is to sense the surrounding medium, and they are designed to consume low energy.

Genetic Algorithm (GA)

The genetic algorithm is a universal optimization algorithm derived from evolution and natural selection, put forward by John Holland and his students at the University of Michigan in 1975 and is based on Darwin's biological theory of "survival of the fittest" and Mendel's principle of genetic change, which is "biological genetic evolution that occurs mainly in the chromosome, and represents the intelligent exploitation of random search within a specific search space to solve a problem.

GA works with encoded parameters and not with the parameters themselves, genes are used to represent the encoded parameters, the parameters in GA can be represented and encoded in various ways such as binary, decimal or any other base, a predetermined set of genes is called a chromosome. The algorithm deals with a group of individuals, where each individual represents a potential solution represented as a chromosome, each Groupand develops through a number of generations in which the matching function is applied to each member (chromosome) of individuals.

Chromosome structure: each sensor or node in the network has 3 coordinates namely x, y and z and therefore our chromosome consists of 3 genes, one for the x axis, the other for the y axis and the third for the z axis which represent the length, width and depth of the node.

The basic idea of the genetic algorithm:

1) The production of a randomly generated indigenous population whose number is fixed (N).

2) The production of the next generation through crossing, change and mutations between individuals.

3) The formation of the new population of individuals N of the 2nd generation.

4) Produce the next population by repeating step 2 and 3 until reaching the individual who meets the conditions.

Figure (2) shows the box diagram of the stages of the genetic algorithm:

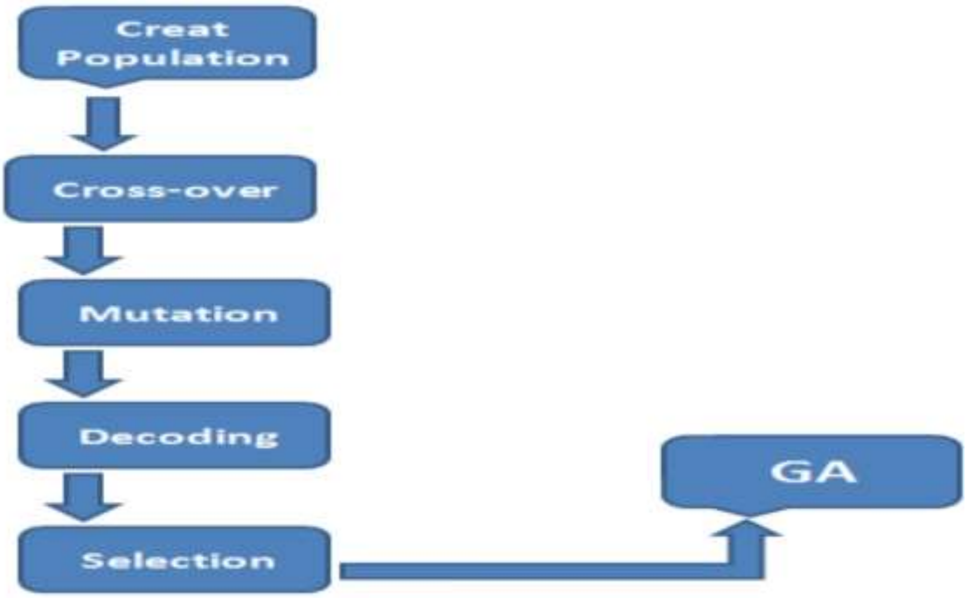

Figure 2: the box diagram of the stages of the genetic algorithm

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Fitness Function

- How to define the matching function in the genetic algorithm?

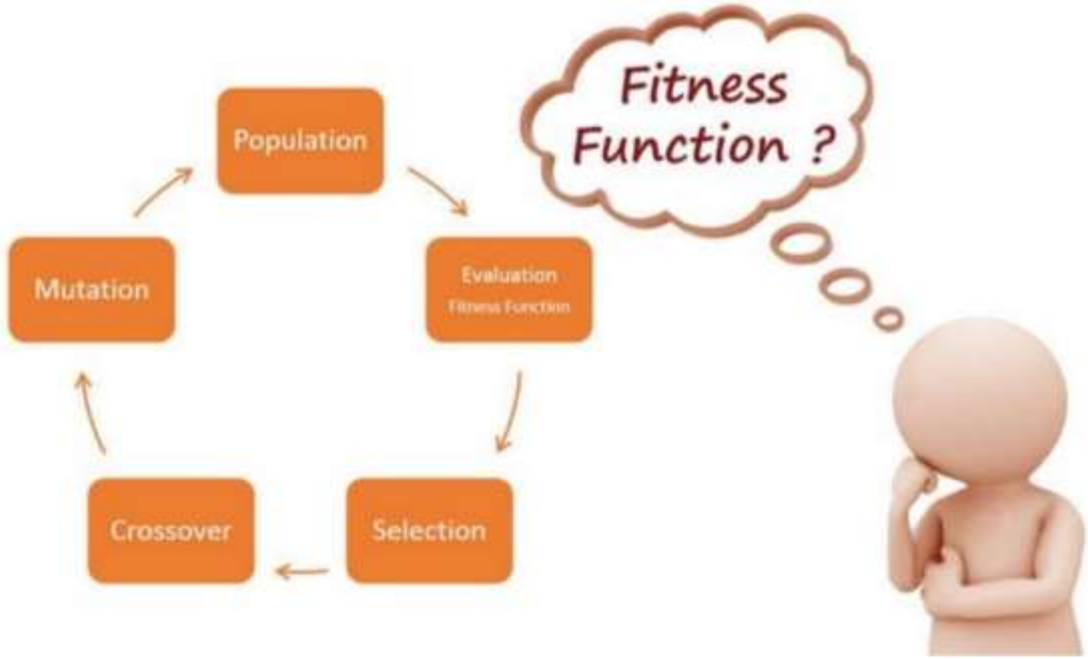

Figure 3: Fitness Function

- What is the Fitness Function ?

The matching function (also known as the evaluation function) evaluates how close a particular solution is to the optimal solution of the desired problem (it determines the suitability of the solution).

- Why do we use the Fitness Function?

In genetic algorithms, each solution is generally represented as a string of binary numbers, known as a chromosome, we have to test these solutions and come up with the best set of solutions to solve a particular problem. Therefore, each solution must be given a score, to indicate how close it is to meeting the general specifications of the desired solution, this result is generated by applying the matching function to the results obtained from the tested solution.

Genetic algorithm business cycle

The genetic algorithm goes through three stages: selection (Selection), crossover (CrossOver) and mutation (Mutation) as shown in Figure (4)

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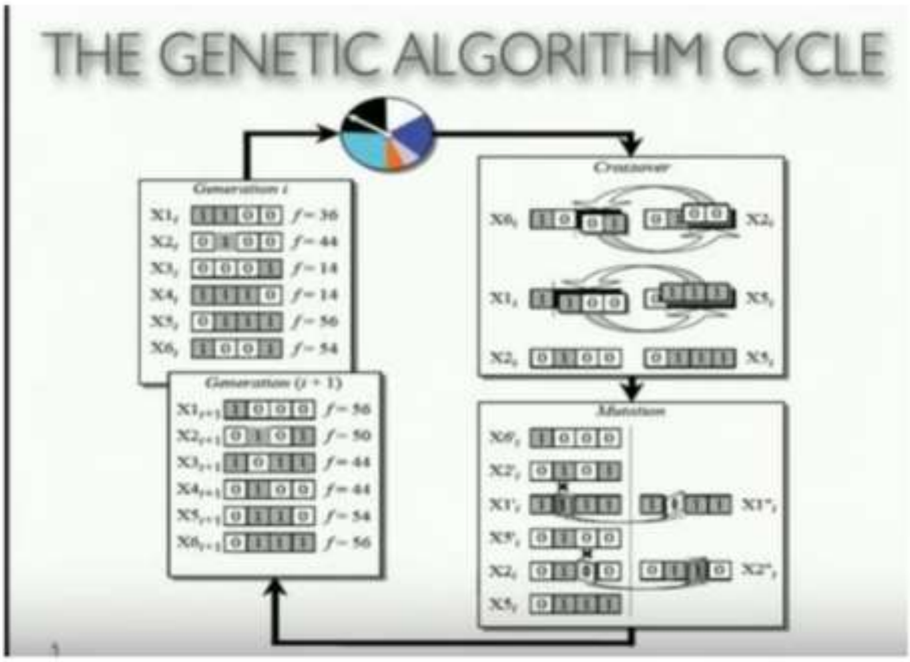

Figure 4: the working cycle of the genetic algorithm

Selection: there are several ways to choose, in this research we used the roulette wheel method.

- Roulette wheel selection (RWS): it is the easiest and simplest way to implement and consumes the least amount of time.

- The probability that an individual of the parents chooses to cross or to have a crossover between them is given by the following relationship:

$$p(i) = \frac{f(i)}{\sum_{j=1}^{n} f(i)}$$

or it is possible that the choice is made randomly by means of a roulette wheel, as an example of the following Figure (5):

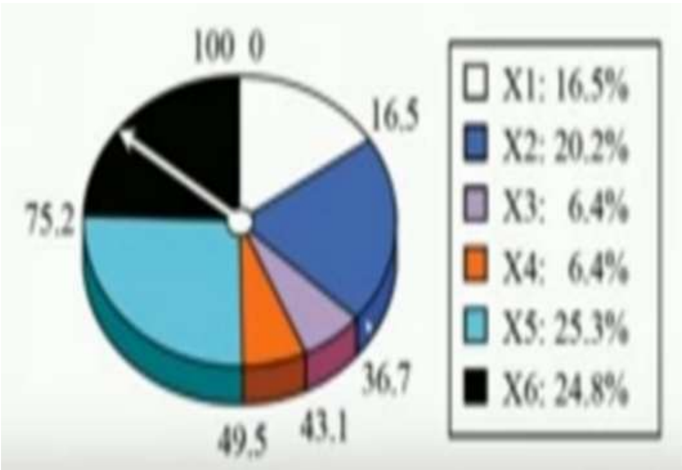

Figure 5: roulette wheel method

Since the White Arrow will rotate randomly and stand at a certain color, it is logical that the one whose percentage is larger, i.e. its area or value is higher, will have a greater chance of choosing it.

Crossover: it is a random exchange of bits between two solutions or two chromosomes based on random values of the probabilities of its occurrence, as the program will give random values of the probabilities of Crossover,

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i.e., the probability of crossover, coded by pc, and with very small values, if it is X, for example, where x is the value of the fitness value of a particular chromosome without any change in its bits.

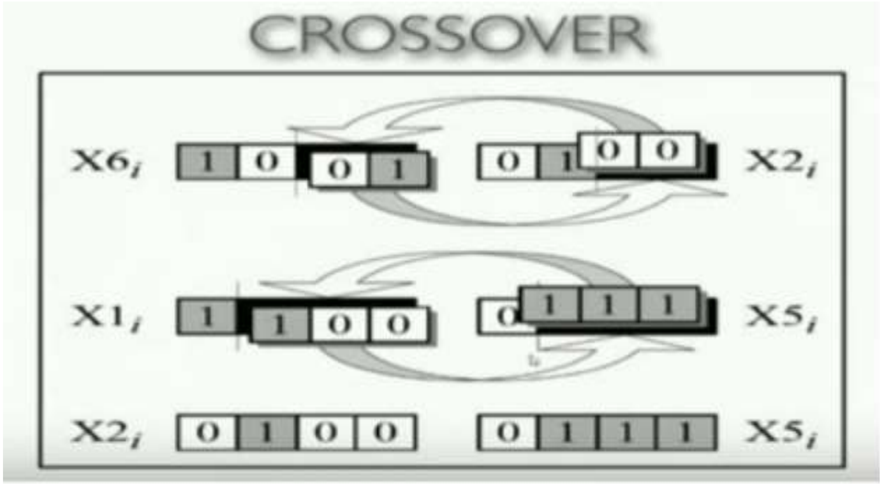

Figure 6: the crossover

Mutation: it is a change of a certain bit in a chromosome from zero to one or vice versa based on random values of the probabilities of its occurrence, as the program will give random values of the probabilities of mutation, i.e. probability of mutation and its symbol pm, and with very small values, if it is X, for example, where x is the value of the fitness value.

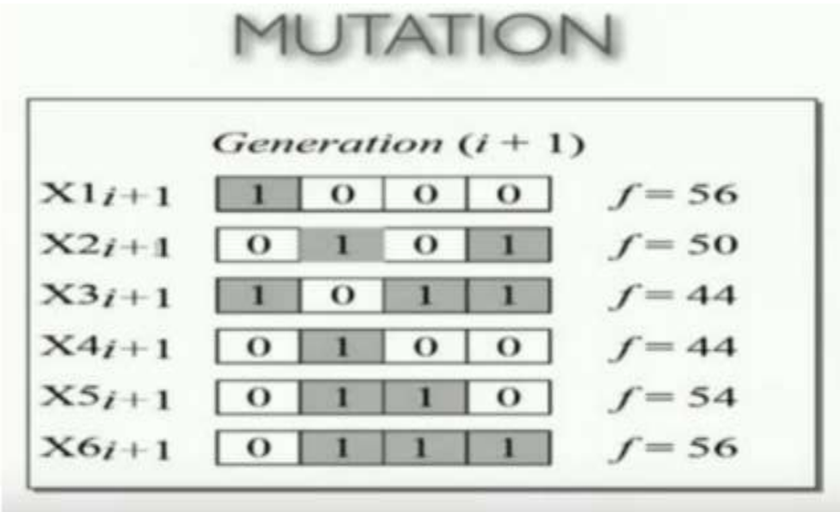

Figure 7: the mutation

the proposed model

The proposed system implants the genetic algorithm within the sensors so that they are able to transmit their location to the floating nodes.

We will study the case with the presence of several anchor nodes to see the effect of the number of nodes on some parameters in the algorithm.

Network diagram

Figure (8) shows the working scenario of the network we are working on, which consists of:

- A floating node that has control and monitoring tasks.

- One, two, three or four knots act as anchor nodes and their location is quite specific and known.

- Several randomly distributed nodes whose locations are requested at any moment.

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2. Network information

1 - Number of sensors: 4 or more sensors representing non-positioned nodes are encoded from S1 to S4.

2-Service Access Point: a single point represented by a floating node.

3-channel communication: wireless network adopts ultrasonic wave (UAN).

4. Contact technique: ultrasonic longitudinal propagation.

5-propagation losses: calculated according to the Standard propagation loss Model

6. Power Mode: Super 40dbm transmission power- (underwater waves are acoustic only).

7. Connection mode: the connection is active when needed.

8-location of the network: marine environment transmission and reception losses are governed by the factors of depth, water viscosity and dimension.

9-network topology: hierarchical.

3. Results and discussion

In this research, the genetic algorithm is implanted within the sensors so that it becomes able to transmit its location to the floating nodes, we will study the change in accuracy and other parameters by increasing the number of anchor nodes.

Study of the change of algorithm parameters on the accuracy of positioning

Having found that the use of a {B anchor points will give the best accuracy in determining the location of the sensor, we will study the influence of some algorithm parameters on this particular case (the presence of four anchor points).

Accuracy change with initial sample size change

The algorithm was implemented with a sample size of 50,100,200,500,1000,2000 individuals to find the coordinates of a sensitive unknown location relative to the algorithm but by default located in the place (14,14,14) and the results were as follows:

Table 1: error rate and time taken to change the base sample census

Initial pop	X	Y	Z	Error(%)	Time(sec)
50	14	11	13	3.5	2.76
100	12	15	15	2.8	2.91
200	13	13	13	2.1	3.25
500	15	13	14	1.4	4.3
1000	13	14	14	1	7.7
2000	14	14	13	1	14.2

We note that the accuracy of the algorithm increases significantly when the initial sample count exceeds 200, while there is no significant change above 1000.

Error ratio change with initial sample size change

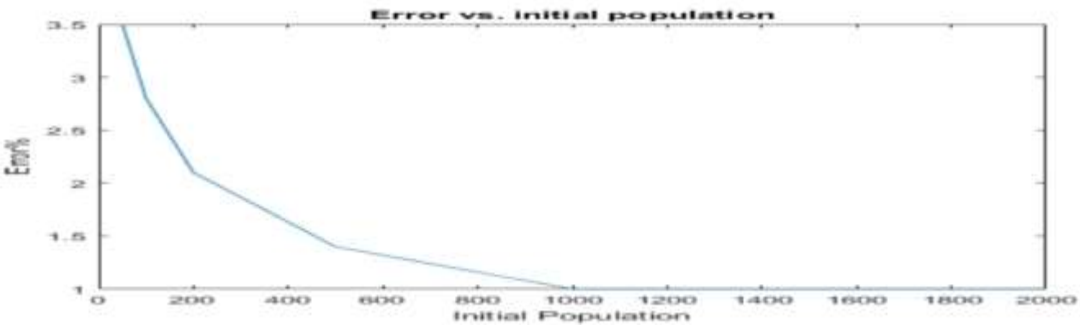

Figure 9: error ratio as the number of initial sample members changes

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We note that the error rate increases with the increase in the number of respondents.

Time change with initial sample size change

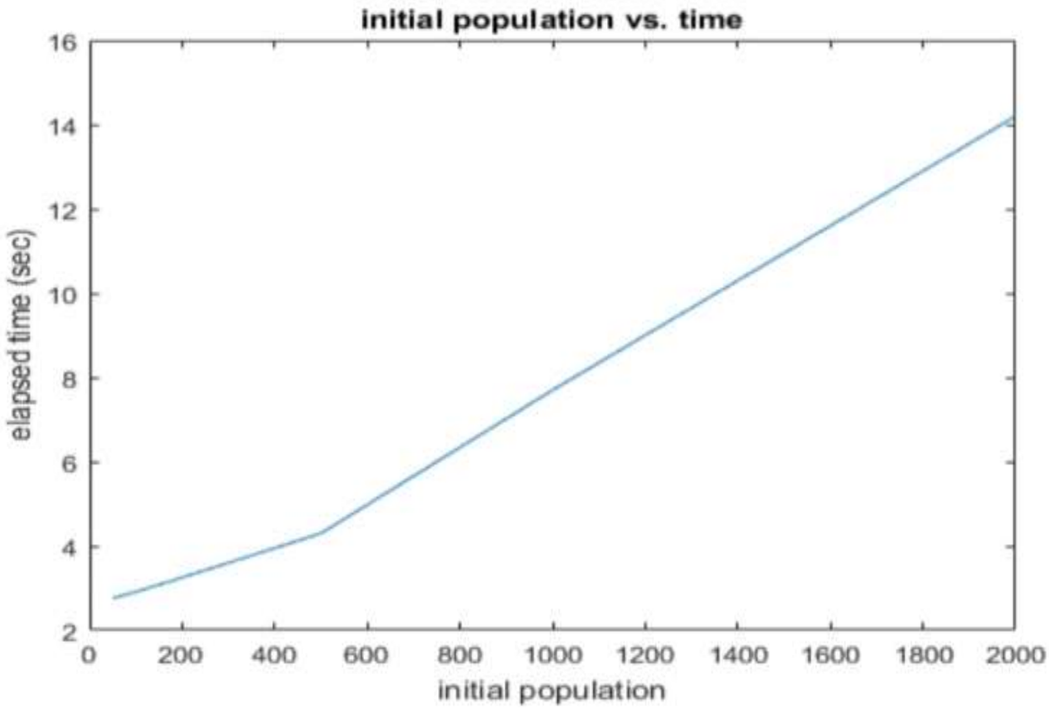

Figure 10: the time taken to implement the change in the number of sample members

We note that the larger the number of respondents, the longer the execution time.

Accuracy change by mutation rate change

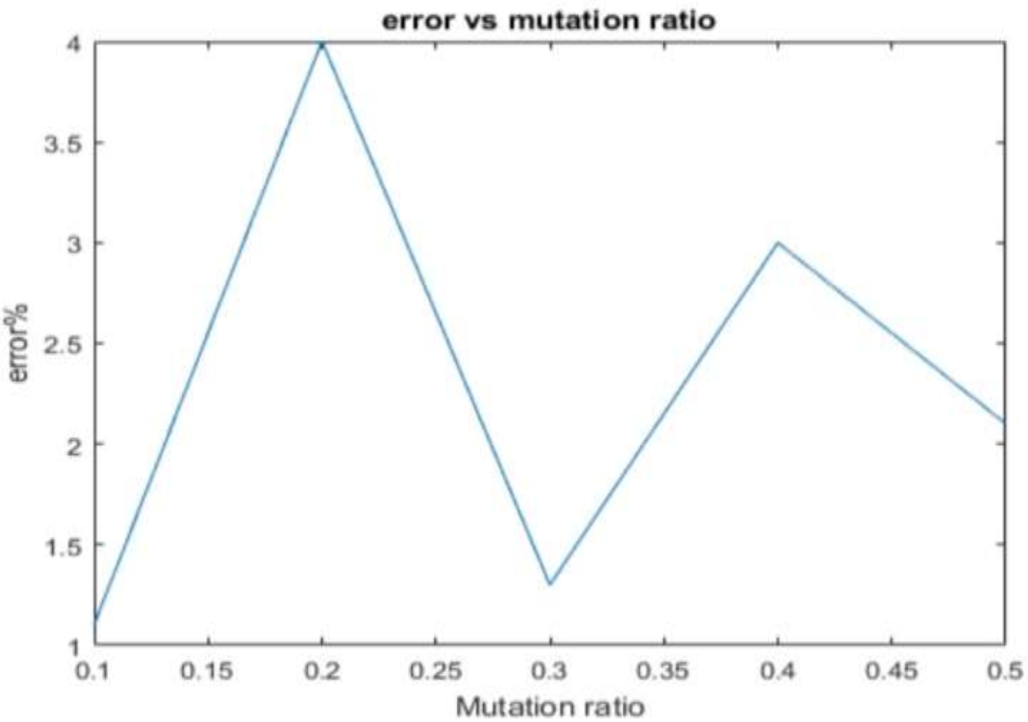

Figure 11: accuracy change

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The mutation rate did not affect the accuracy clearly, as the error sometimes increases with an increase in the mutation rate, and other times decreases, so any ratio can be used.

4. Conclusion

The use of a genetic algorithm led to the identification of a sensitive location of an unknown location depending on the presence of anchor nodes with location information.

The accuracy we have obtained is very good accuracy in most marine environment applications and is definitely less expensive than using high-precision methods such as satellites.

In this research, the change of accuracy and time parameters was studied when determining the optimal location of nodes of unknown location in a network of underwater wireless sensors by genetic algorithm, where it is possible to determine the coordinates of unknown nodes in the network (length-width-depth) and choose the best location for these nodes by moving from one generation to another and deleting inappropriate values or coordinates to reach the last generation that achieves the desired, and all these operations are accomplished by the genetic algorithm in record time.

The results show that:

1- The current algorithm gives the highest accuracy with a minimum error.

2- The result also indicates that the genetic algorithm provides the best estimate of the location with the lowest execution time.

3- An additional increase in the anchor knot increases the time but does not improve accuracy.

4- This algorithm helps to reduce the time and achieve the best location.

5- We can say that the positioning of nodes in the network of underwater wireless sensors is still an important challenge.

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