International Journal of Science Academic Research
Vol. 01, Issue 08, pp.525-531, November, 2020
Available online at http://www.scienceijsar.com

ISSN: 2582-6425

Research Article

PRESENTING A MODEL TO DETERMINE THE TREATMENT OF WOMEN WITH BREAST CANCER IN IRAN USING DATA MINING ALGORITHMS

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Received 17th September 2020; **Accepted** 25th October 2020; **Published online** 16th November 2020

Abstract

Breast cancer is one of the most common types of cancer and the most common type of malignancy in women, which has recently had a growing trend. In patients with this disease, nutrition therapy is always one of the best and least risky treatments for breast cancer, but the most significant problem of the doctor is choosing the type of treatment for breast cancer. This article presents a method to help select the type of treatment regimen. For evaluating the proposed method, data from 683 cases breast cancer patients consist of 20 characteristics of each disease were used. After the pre processing and data preparation phase, a prediction model was proposed for nutritional therapy selection by decision tree optimization using the cuckoo algorithm. In this study, it represents that the use of the cuckoo optimization algorithm can increase the accuracy of the decision tree algorithm. The specificity and sensitivity of the proposed model were 94% and 91%, respectively. In this model, only 7% of the suggested nutrition types to patients are incorrect. For evaluation, using two algorithms, the nearest neighbor and the decision tree J48, the proposed algorithm examined, and the results show that the proposed algorithm has higher accuracy.

Keywords: Breast Cancer, Decision Tree, Cuckoo Algorithm, Diet.

INTRODUCTION

Breast cancer is the most common cancer in women in the United States and the second leading cause of cancer death in the United States (Jemal *et al.,* 2006). According to the World Health Organization in 2011, breast cancer is the fifth leading cause of cancer death in the world, with about 508,000 deaths out of about 54 million deaths in the world.This cancer is the leading cause of cancer death among women. According to the American Cancer Society report in 2012, the number of new cases of breast cancer among women in this country was 232,340 cases. In addition, the mortality rate of breast cancer among women in this country estimated at 39,620 (CDC). In general, one in eight women will suffer breast cancer in their lifetime, and one in 36 people will die from breast cancer. The treatment for breast cancer first is by surgery and then chemotherapy, and in some cases, with radiotherapy. In cases where the large size of the cancerous mass may cause removing the entire breast, chemotherapy is given before surgery to reduce the size of the tumor, which is called Neoadjuvant Therapy.In some women with breast cancer, hormone therapy, or monoclonal antibodies are also used to treat it .Many chemotherapy regimens for the treatment of breast cancer patients have been in detailed measuring within clinical trials, and different combinations of these drugs studied in detail for several patients. The results of these studies show that choosing the right type of chemotherapy regimen is an important decision that affects the patient's treatment and survival rate.There are four treatment regimens for healing breast cancer: A diet with control of excess fat and calories, a diet of significant nutrients and phytochemicals, a diet of vitamins and minerals, and a soy treatment regimen.In Iran, significant nutrient and phytochemical diets and soy treatment regimens are generally used (Mousavi *et al.,* 2007).

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In this article, we intend to use the data of past patients and data mining algorithms to provide a method that can accurately predict the best treatment regimen for the patient. We also try to increase the accuracy of the algorithm by presenting a new technique.

The next sections of the article are as follows:

In Section 2, we review the research background and works that has been done in this field so far. In Section 3, we present and explain the proposed method. In the following, in sections 4 and 5, we describe the results of the proposed method and the general conclusion.

Research background

Delen et al. used artificial neural networks, decision trees, and logistic regression to develop a breast cancer prediction model by analyzing and taking advantage of the massive databases collected from the famous Wisconsin database (The Surveillance, Epidemiology, and End Results). The results of their research showed that the decision tree algorithm for extracting knowledge from existing data is before other methods, and the results obtained from it were close to reality (Jones *et al.,* 2005). In their research, as shown in figure 1, they examined the factors that affect breast cancer .Yi and Fuyang also applied SVM to data from the Wisconsin Hospital to discover patterns of diagnosis of breast cancer treatment. The results showed that SVM was a suitable method for detecting patterns of breast cancer, and the results were consistent with the available and real evidence (Martín *et al.,* 2013). Landin et al. (2006) developed a prediction model of 5, 10, and 15-year survival of breast cancer patients using the artificial neural network, classification trees, and logistic regression. The input variables were tumor size, lymph node status, tissue type, Tubule formation, tumor necrosis, and

age.Eventually, they concluded that classification trees, as well as logistic regression, are much more suitable for clinical interpretation (Jones *et al.,* 2006). Pendarker *et al.* (1989) used several data mining methods to examine patterns in breast cancer.In this study, they showed that data mining can be used as a valuable expression in identifying similarities (patterns) in breast cancer for diagnosis, prognosis, and treatment (Gail *et al.,* 1989). These studies are examples of the application of data mining in the medical sciences to predict disease. Razavi et al. utilized data mining methods to analyze non-compliance with clinical guidelines in treatments of breast cancer and finally obtained four rules using decision tree induction (DTI). Finding patterns of non-compliance with clinical guidelines using these rules is a suitable alternative to manual methods. The resulting rules, based on clinical guidelines, are useable inside the knowledge base of decision-making systems for warning in case of non-compliance with clinical guidelines (Razavi *et al.,* 2007). One of the considerations in the treatment of breast cancer patients is the change in chemotherapy regimens over time.The study by Jiordano *et al.* (2012) explained decreasing the use of Anthracycline-based chemotherapy regimens, and alternatively, the majority of breast cancer patients used Taxane-based chemotherapy regimens (Jiordano *et al.*, 2012).

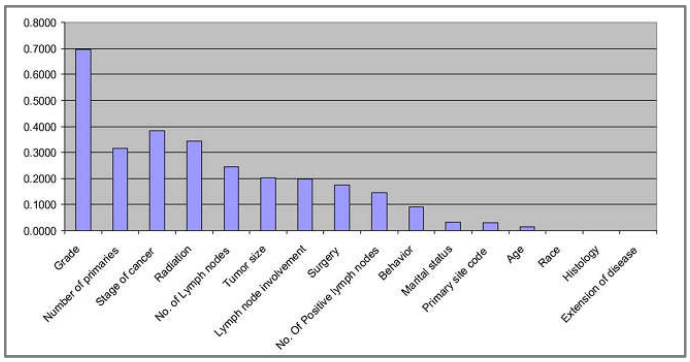

Figure 1. Parameters affecting cancer in research by Delen et al. (2005)

Proposed Method

As observed in the research background, the decision tree is one of the most powerful algorithms in the field of data classification of this type of disease, and it has higher accuracy than other utilized algorithms.However, since the decision tree algorithm uses a greedy (entropy) method to construct the tree, this paper suggests improving the accuracy of the tree by using an optimization algorithm.In this paper, we propose a method in which changes the criterion for selecting a node in tree construction from entropy to a combination of entropy and cuckoo optimization algorithms where the accuracy of output results is better than using the decision tree.The cuckoo algorithm power in solving the problems that are in consecutive space, in comparison to similar algorithms, is the main reason for choosing that. Then, in sections 3-1, 3-2, and 3-3, describing the proposed method.

Decision Tree

The decision tree is one of the most widely used and useful methods utilized for inductive inference (Martín *et al.,* 2013). The decision tree is a non-parametric method with a hierarchical structure of data and supervised learning that using a divide-and-conquer algorithm is implemented. In the decision tree, the criterion for selecting a node is a mathematical relation called entropy, which at each stage tries to choose the best node, regardless of previous choices, which this is a greedy choice.As mentioned earlier, the decision tree algorithm uses a greedy method to build tree nodes. Greedy algorithms have high speed in solving problems but do not guarantee the optimal answer. Since in medical problems in most cases, the answer accuracy (optimality) is very significant, so here we tried to use an optimization algorithm to increase the accuracy of the tree. In this paper, we changed the criterion for selecting nodes in decision tree construction from entropy to cuckoo optimization algorithm.

Cuckoo algorithm

The human desire for achieving perfection is the reason for the development of optimization science. Human wants to visualize and achieve the best. However, since he knows that not able to know all the conditions making the best, in most cases, instead of the best answer or the absolute optimal, he is satisfied with a satisfactory answer.For this reason, have been proposed several approaches to design acceptable quality solutions under tolerable time limitations.Accordingly, some algorithms can ensure that good answers are found at a certain distance from the optimal answer, which are called approximate algorithms. One of these algorithms is the cuckoo optimization algorithm. The cuckoo algorithm, which was developed in 2009 by Yang and Deb (2009), is inspired based on the life of a bird called the cuckoo. The cuckoo algorithm was later fully developed in 2011 by Ramin Rajabiun in more detail (Rajabioun, 2011).

Categorize using decision tree optimization

A suitable data structure is necessary first to solve the problem with the decision tree optimization method. After designing this data structure, the decision tree optimized using the cuckoo algorithm. In the following, sections 3-3-1 and 3-4 explain the proposed classification method.

Design a data structure for the decision tree

The decision tree uses a two-dimensional array to store its nodes, in which the number of columns is the size of the nodes, and the number of rows is three. For example, an array of eight columns and three rows is required to store a decision tree in Figure 2 .The array first row can be in two states. Which the positive value means a non-leaf node and the negative value means it is a leaf node.Thus, in Figure 2, columns 1, 2, and 6 represent non-leaf nodes, and the remaining columns represent leaf nodes .The second row refers to the parent index of each node. For example, in the second column of Figure 2, the value of the second row is equal to one, which shows the parent of the second node is in the first column. In addition, if the second column has a value of zero, it means the root node.The third row shows the value of the edge of the tree. For example, in the sixth column of figure 2, the value of the third row is three and shows that the edge of this node has a value of three. Moreover, if the third column has a value of zero, it means the root node .The procedure of building a decision tree is Inorder. Meaning that, first, the root side is created, then the node on the left, and finally the node on the right. In the decision tree, entropy is the criterion for choosing. The algorithm ends when there are no more samples or no more features (using the majority-voting rule).

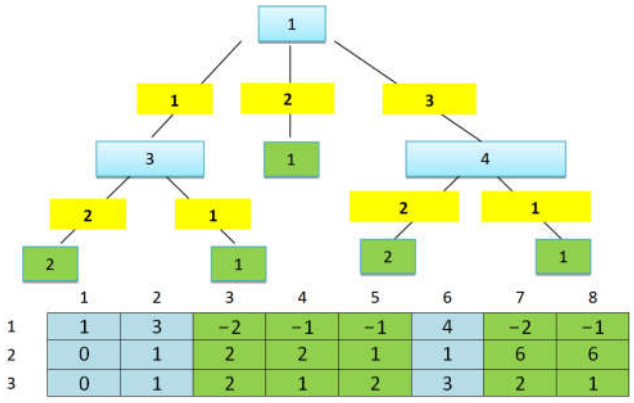

Figure 2. Proposed structure for storing decision tree

Optimization of the decision tree using the cuckoo algorithm

There are two main problems in the proposed decision tree algorithm. First, the proposed algorithm is greedy, and the answer may not be as optimal as expected, and the second problem is over fitting occurs .Therefore, in this paper, using a combination of cuckoo optimization algorithm and entropy instead of entropy was suggested to be the selection criteria change from entropy. All the different states of drawing the tree and their accuracy (optimality) must get examined to find the optimal tree.We call each of these states a permutation. Each permutation is an array whose size is equal to the number of tree nodes, and its members are tree nodes. The problem of finding the optimal tree is an NP-complete and the order of factorial. For example, based on the entropy criterion, as shown in Figure 2, the first column is selected initially, then the third column, and at last, chosen the fourth column. Thus, the selection sequence of the standard algorithm is 1, 3, 4 . There are four factorial different ways to draw a decision tree. Therefore, it should use the meta-heuristic algorithms to prevent search in the entire search space. In this research, we used the cuckoo optimization algorithm. Using the cuckoo algorithm, we generate a permutation equal to the number of problem columns (tree nodes); figure 3 shows an example of a permutation.

1	2	3	4
2	4	1	3

Figure 3. Creation of a permutation from 4 elements

Then, based on the permutation, we place the second column instead of the first column, place the third column instead of the fourth column, place the first column instead of the third column, and the tree changes as shown in Figure 4.

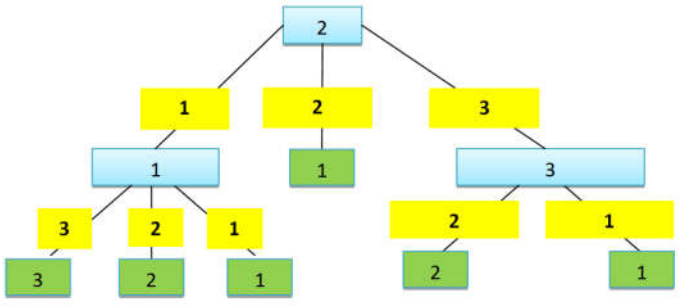

Figure 4.New tree obtained by changing the elements permutation

As can be seen in Figure 4, changing the selection of columns (properties) changes the structure of the tree. And it may be the cause of an increase or decrease in the number of nodes.The production of different permutations is the same as the problem of the traveling salesman (in the traveling salesman problem there are a number of cities and we know the cost of going directly from one to another. It is desirable to choose the least expensive route that starts from one city and passes through all cities exactly once and returns to the starting point. If we name the cities with numbers from 1 to N, so the result of the traveling salesman problem answer is a permutation of numbers (The difference is that instead of calculating the distance for the fitness function, plotting the tree, then the accuracy of that tree is selected as the fitness function .The traveling salesman problem is discrete, but the use of the cuckoo algorithm is in the consecutive data. There is although a discrete version, but it does not have the power of consecutive data; hence, the modification of the Habitat structure (the structure of each answer from the cuckoo optimization algorithm called Habitat) has been as follows to generate the permutation problem. Habitat size is the number of permutations (number of features) and its values are between 0 and 1 and that initially generated randomly (Figure 5).

1	2	3	4
0.9058	0.1270	0.9134	0.6324

Figure 5. Proposed Habitat structure

Then, put one instead of the least element, put two instead of the next element value, and so on. Figure 6 shows the result.

1	2	3	4
3	1	4	2

Figure 6. Converting a Habitat structure to a permutation structure using sorting

Now with the help of the cuckoo algorithm, able to solve the problem. Figure 7 shows an overview of the proposed method, and Table 1 shows the parameters of the cuckoo algorithm. Calculation of the next generation parameters, the initial population number, minimum and maximum spawning, number of offspring, number of spikes, coefficient of motion, and maximum cuckoos have been by trial and fail, and put the value of other parameters based on the characteristics of the problem.

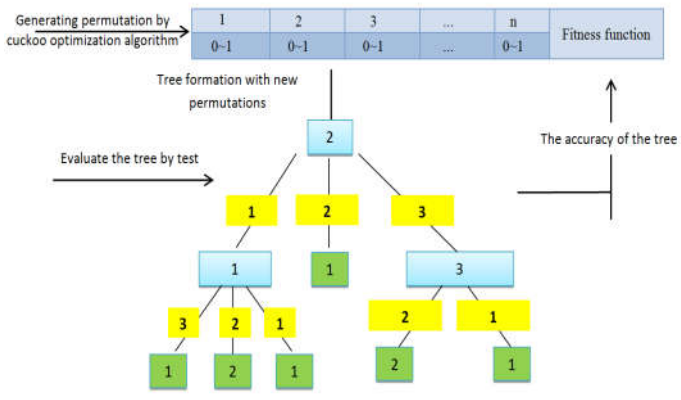

Figure 7. Outline of the proposed method

Table 1. Cuckoo Algorithm Parameters

Row	Parameter Value	Parameter Name
1	The initial population size is equal to the number of attributes and is a number between 0 and 1	Habitat Initial Population
2	Algorithm Accuracy for generating a tree	Fitness Function
3	10	initial population number
4	Lower bound = 0 and higher bound = 1	HabitatLower and higher bound
5	Minimum spawning = 2 and maximum spawning = 3	Minimum and maximum spawning
6	10	Number of generations
7	Value between 2 and 3	Number of clusters
8	Value between 0 and 1	Movement coefficient
9	30% increase in population compared to the previous generation	Maximum cuckoos for the next generation

Table 2. Characteristics of breast cancer patients belonging to the database used in this article

Row	Name	Detailed information
1	Age	Patients are between 40 and 80 years old
2	Maritalstatus Single Marrid Divorcee Widow	Marriage status Single Married Divorced Widow
3	Menopause status Before Menopause After Menopause Beginning Menopause	-
4	Education Illiterate Elementary Middle Diploma Academic	-
5	Surgery Keeping breast Remove breast Remove some of breast	-
6	Chemotherapy	Values between 1 to 9
7	Radio therapy	Values between 1 to 9
8	Hormone therapy	Values between 1 to 9
9	Hormone therapy kind	Type of hormone therapy: There are 4 types of consumed drugs that have been with a doctor's diagnosis
10	Size of tumor	Tumor size in centimeters is between 1 and 10.
11	lymphatic tumor	Tumor size in Lymph node
12	Relapse	Recurrence of cancer after surgery
13	clinical step	Values between 1 to 5
14	new clinical step	Based on standard methods, new clinical stages are 5 days. But there are also changes on these 5 days that stated in case of it.
19-15	Result of four tests	HER-9 P53 PR ER
20	diet therapy	As can observe in Section 2-2, there are four treatment regimens, and the only recommended treatment regimens in Iran are 2 and 4

Results of the proposed method

Performing experiments and prove their results is one of the most significant parts of a theory. MATLAB software on a system with a 4GH processor and 6GB memory utilized to test the proposed method. These collected data were from the Ahwaz Oil Hospital.

Used Data

In this project, we usedcollected data from 809 breast cancer patients of the Ahvaz Oil Hospital .In this database, as shown in Table (2), each patient considered to have 20 characteristics . Unfortunately, considering the significant missing value of data in this collection, only 683 patients' information is useable. Therefore, only 683 records of breast cancer patients used in this article.

Preprocessing

In the following, describe the three applied stages of preprocessing to the data. The stages are estimated data loss, dimensionality, and discretization. To perform preprocessing, utilized the SPSS.V20 software.

Estimates missing values: To estimate the missing data, the Expectation-Maximization (EM) method is used. The most famous statistical method for calculating the missed data is the EM method. McLachlan (Tenório *et al.,* 2011) developed this method in 2007. It is one of the most common missing data prediction algorithms in which the value of one variable being used to assign other variables (Expectation). Then the algorithm tests whether this value is the most probable (Maximization).If not, it assigns a more probable value.This process continues until it reaches the most probable value. EM is a suitable technique that is common in data analysis. EM can overcome some of the limitations of other methods like mean and regression.Unlike the mean and regression methods, the EM method considers the standard error (standard error, the standard deviation is a statistical sampling distribution used to estimate the standard deviation obtained from several samples (Ruiz *et al.,* 2011)) in the problem (Kim *et al.,* 2011).

Table 3. Comparison of proposed algorithm and decision tree algorithm based on four criteria of confusion matrix, sensitivity, specificity, accuracy and execution time for training and testing data

Decision tree andCuckoo algorithm						Decision tree						Training and testing data segmentation		Row
Time in seconds	Accuracy	Specificity	Sensitivity	Confusion Matrix		Time in seconds	Accuracy	Specificity	Sensitivity	Confusion Matrix				
41.9002	%100	%100	%100	275	0	0.0620	%100	%100	%100	267	0	Training	40-60	1
				0	134					0	142			
	%91.21	%92.55	%90.50	162	7		%89.01	%89.25	%88.51	166	10	testing		
				17	87					20	77			
57.2744406	%100	%100	%100	308	0	0.0857536	%100	%100	%100	308	0	Training	30-70	2
				0	170					0	170			
	%93.63	%91.18	%94.85	129	6		%90.69	%86.76	%92.65	126	9	testing		
				7	62					10	59			
76.867181	%98.83	%98.45	%99.06	211	2	0.099459	%100	%100	%100	225	0	Training	2-Fold	3
				2	127					0	117			
	%93.26	%88.50	%95.61	218	13		%92.67	%88.80	%94.91	205	14	testing		
				10	100					11	111			
133.751573	%99.21	%98.57	%99.58	238	2	0.189269	%100	%100	%100	245	0	Training	3-Fold	4
				1	138					0	135			
	%91.45	%84.91	%94.95	188	16		%91.09	%88.12	%92.57	187	12	testing		
				10	90					15	89			
203.854951	%100	%100	%100	273	0	0.282686	%100	%100	%100	276	0	Training	4-Fold	5
				0	154					0	151			
	%87.50	%82.72	%89.71	157	14		%90.66	%88.10	%91.91	159	10	testing		
				18	67					14	74			
260.462161	%99.35	%99.38	%99.34	300	1	0.373323	%100	%100	%100	300	0	Training	5-Fold	6
				2	161					0	165			
	%86.24	%81.94	%88.36	129	13		%90.87	%89.71	%91.39	138	7	testing		
				17	59					13	61			
319.714683	%100	%100	%100	322	0	0.515255	%100	%100	%100	319	0	Training	6-Fold	7
				0	172					0	174			
	%87.30	%84.13	%88.89	112	10		%91.53	%91.53	%91.54	119	5	testing		
				14	53					11	54			
382.960599	%100	100ccc%	%100	336	0	0.564478	%100	%100	%100	334	0	Training	7-Fold	8
				0	180					0	182			
	%88.02	%85.45	%89.29	100	8		%91.62	%92.16	%91.38	106	4	testing		
				12	47					10	47			
452.020309	%100	%100	%100	348	0	0.649599	%100	%100	%100	346	0	Training	8-Fold	9
				0	186					0	188			
	%85.91	%83.33	%87.13	88	8		%90	%89.13	%90.38	94	5	testing		
				13	40					10	41			
533.972962	%100	%100	%100	356	0	0.731513	%100	%100	%100	355	0	Training	9-Fold	10
				0	192					0	193			
	%86.57	%83.72	%87.91	80	7		%86.76	%80.43	%89.89	80	9	تست		
				11	36					9	37			
604.033401	%99.82	%100	%99.73	346	0	0.839930	%100	%100	%100	363	0	Training	10-Fold	11
				1	195					0	197			
	%88.62	%87.18	%89.29	75	5		%86.29	%77.78	%91.14	72	10	testing		
				9	34					7	35			

Reduce dimensions

One of the most famous algorithms called PCA utilized to reduce the dimensions, and it reduced the dimensions count to nine. To reduce the data dimensions PCA technique is the best way to do it linearly. That means, by removing the insignificant coefficients obtained from this conversion, the information lost is less than other methods. The usage of PCA is not limited to data reduction; moreover, utilized in different fields such as pattern recognition and face recognition.In this method, defining new axes coordinate for the data, and the data are expressed based on these new coordinate axes. The first axis should be in the direction where the variance of the data is maximized (means in the way where the data scatter is greater).The second axis should be perpendicular to the first axis so that maximizing the variance of the data. In the same way, the next axes are vertical to all the previous axes in such a way that the data have the most scatter in that direction. Figure 8 shows a schematic view of the dimensional reduction.

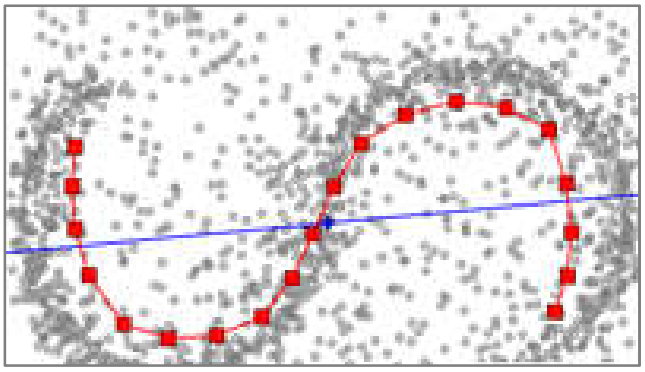

Figure 8. Schematic view of dimensional reduction (Samet, 2016)

Discretization

The data converted to consecutive numbers due to the use of the PCA method to reduce the dimensions, but the decision tree algorithm requires discrete data, so SPSS software utilized to discretize the information.

Evaluation of the proposed algorithm

After preprocessing the data, dividing the algorithm data into training and test data in three ways:

- Sixty percent of the data for training and forty percent of the data for testing
- Seventy percent of the data for training and thirty percent of the data for testing
- consider using the K-Fold method and K-values of numbers between 2 to 10

Then the proposed algorithm applied to the training and test data. Four parameters of Confusion Matrix, Sensitivity, Specificity, Accuracy, and execution time of the algorithm utilized to evaluate the proposed algorithm. Table 3 shows the results .The performance of the corresponding algorithms shows by the Confusion Matrix. Usually, algorithms like decision trees using such representation. Each column of the matrix shows a sample of the predicted value. If each row contains a real (True) instance, Figure 9 shows the Confusion Matrix structure.

		Predicted Class: Yes	Predicted Class: No
Actual Class	Yes	TP	FN
	No	FP	TN

Figure 9. Confusion Matrix structure

The equations of Sensitivity, Specificity, and Accuracy, as seen in equations (4-1), (4-2), and (4-3), calculated using the Confusion Matrix.

$$\text{Sensitivity} = \frac{TP}{TP+FN} \quad (1\text{-}4)$$

$$\text{Specificity} = \frac{TN}{FP+TN} \quad (2\text{-}4)$$

$$\text{Accuracy} = \frac{TN+TP}{FP+TN+TP+FN} \quad (3\text{-}4)$$

As can be seen in Table 3, in the 2-Fold method, the decision tree method best accuracy reached 92.67% of accuracy.

Compare parameters

Now all three parameters are compared and examined separately, and in Figures 10, 11, and 12 the results are seen. For any form of data, each row is divided into training and testing, and the column of each chart is shown as a percentage. As can be seen in Figures 10, 11, and 12, the maximum value of all 3 parameters of Sensitivity, Specificity, and Accuracy is in the proposed method; and the proposed method shows a better performance than the decision tree algorithm.

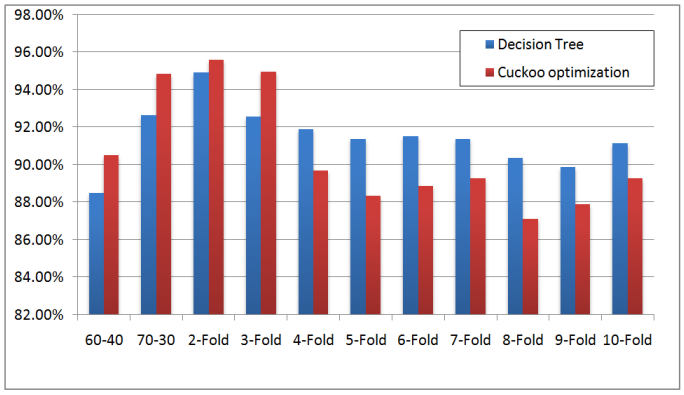

Figure 10. Comparison of Sensitivity parameter for two decision tree algorithms and optimized decision tree using cuckoo algorithm

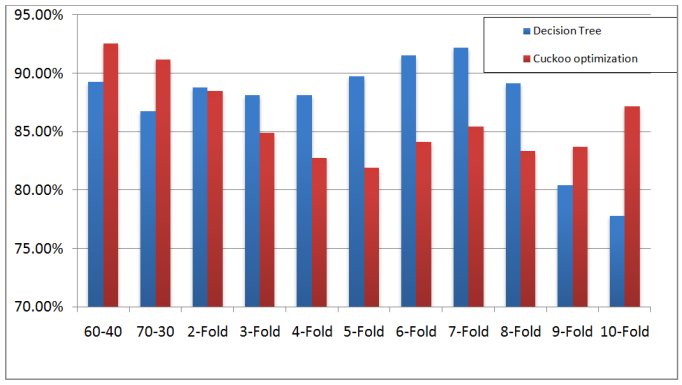

Figure 11. Comparison of the Specificity parameter for the two decision tree algorithms and the optimized decision tree using cuckoo algorithm

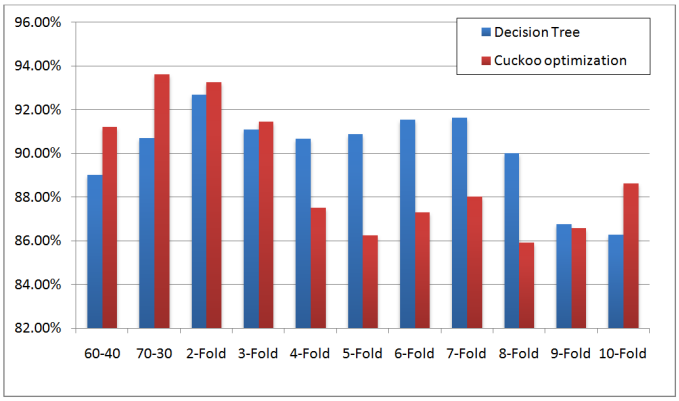

Figure 12. Comparison of the Accuracy parameter for the two decision tree algorithms and the optimized decision tree using cuckoo algorithm

Comparison with other algorithms

To compare the proposed algorithm with other algorithms, due to the uniqueness of the data type, using Weka software, we selected the two nearest neighbor algorithms and the J48 decision tree, and Table 4 shows the output of which. As can be seen in Table 4, the proposed algorithm performs better than other methods in three aspects: Sensitivity, Specificity, and Accuracy.

Table 4. Comparison of the proposed algorithm with the two algorithms of the J48 tree and the nearest neighborhood

Accuracy	Specificity	Sensitivity	Type	Algorithm	Row
%96.2343	%95.3216	%96.7427	Training	Decision tree J48	1
%88.2979	%90.2439	%87.7551	Testing		
%94.9791	%92.9825	%96.0912	Training	Nearest Neighbor Algorithm	2
%82.4468	%73.1707	%85.034.	Testing		
%100	%100	%100	Training	Proposed algorithm	3
%93.63	%91.18	%94.85	Testing		

Conclusion

This article presented a method for diagnosing the type of nutritional therapy for breast cancer patients, and it proved that this method capable of determining the appropriate treatment regimen for the patient with high accuracy. In addition, in this article, we tried to increase the accuracy of this method as much as possible by presenting a hybrid algorithm (optimized decision tree with the cuckoo algorithm). Finally, we tried to show the efficiency of the algorithm by comparing the proposed algorithm with the decision tree algorithms j48 and the nearest neighbor. Data mining algorithms in the field of medicine should be appropriate in terms of two parameters Sensitivity and Specificity. If the value of one of these two parameters is low, the algorithm is not acceptable. This paper concluded that both Sensitivity and Specificity parameters are capable of being optimized using combining the two decision tree algorithms and the cuckoo optimization algorithm.

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