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Diagnosing Diseases via Artificial Intelligence Powered by New Hybrid System

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Abstract:
In this article a hybrid system based on Class Attribute Interdependence Maximization (CAIM) discretization algorithm and normalization is developed for medical decision support system to increase accuracy rates of classifiers on heart disease dataset. Our study is tested on statlog dataset that is taken from UCI. One of the aim of our work was to help any general practioner and other doctors to predict a heart attack that will happen sooner or later for any citizen who suffers from the disease. In this project, we made 4 different works. After getting UCI heart disease datasets we discretized them with CAIM and after this process we normalized its numerical attributes for better results. We used these normalized records in 4 ways. First we used them in a structure that starts with CAIM algorithm and ends with NN's. The solution shows how CAIM help us to find better result. Our result was 87.78% correctness. If we did not use CAIM the result was 85.18% (NN). Then CAIM is used with SVM. Almost 86.66% was found. If we did not use CAIM the result would be 84.81%. First result (CAIM + NN) made us happy.

Keywords: Artificial Neural Networks, CAIM, Expert System, Heart Diseases, Medical Decision Support System, Normalization, Support Vector Machines

I. INTRODUCTION

In this article, a system using NN's and SVM were used. The dataset was discretized with CAIM and normalized. Accuracy of results of medical decision support system was increased doing so. We tried to help practioners and other doctors about diagnosing heart issues. We wanted to help to healtcare system where doctors couldn't go or practioners have little information about these problems to pre-diagnose whether or not people really have heart disease according to various examination results. Our system- a structure based on neural networks, caim, normalization and svm- which predicts heart problems was introduced. After getting records from UCI we discretized and normalized them to make better accuracy. Then we used these normalized records in 4 ways. First we used them in a structure that starts with CAIM algorithm and ends with NN's. Our result was 87.78% correctness. Second structure was starting CAIM and ends SVM classifier. CAIM here have same meaning doing discretization of numerical attributes. CAIM and SVM result was 86.67%. We calculated separately NN and SVM also. To find CAIM's effect to them. We measured that NN's can find solution 85.18% accuracy and SVM find 84.81% accuracy. While validation of classifiers reliability we used 10-fold cross-validation. So we found a way for better result for this research. We also find CAIM is a good way to discrete. And normalization converts numerical values between 0 and 1 in a statics way. The next section named Preliminaries NN's, SVM and CAIM methodologies and performance Criteria is explained. In the developing section we introduced hybrid system and we explained how we inserted our preprocessed datasets into our medical disease prediction system. In the following section labelled experimental results and discussion we gave results about our works and comparison with literature. Last section named conclusion we made a summary of our article. In this article, we used UCI records that were collected from hospitals. On any record; the patients whose information were recorded between certain dates and time were gathered in a table and doing so UCI records help us our project procedures to be shortened. Otherwise we needed to find these records from hospitals and we would take their consent. It is almost difficult. We would need to find these attributes any way and we needed to collect them by us like a nurse. And we could only find a few attributes. A few attributes may be used to find some researches but will not help predict to heart attack. These hospital records are not collected for reseachers to find something and hospital management, doctors and nurses will not accept to measure our attribute requests. By investigating UCI datasets [20] we found many different attributes that help heart problems and any other statistics. Over 250 patients were taken into consideration. The accuracy of our studies was increased by taking the most studied data researchers chose to use. We based our study on a international database that can be downloaded and investigated easily from anywhere.

New Technologies able to predict important diseases more precisely than specialists. This tech can reduce expenses. Patients will be cured rapidly. Artificial techs are accepted rational in all branhes of science. Cardiac doctors may do their works well, but doctors can make some mistakes. Cardiacs understand if there is a problem with patient looking at of patient's heart-beats. Over 75 % of their predictions is correct. Below 25 % of them are not and need to be corrected. Artificial Intelligence prediction automations can beat doctors and reduce huge amount wasted all over the world. A complicated study on genetic factors that affect heart attacks and strokes were generated by ai. Records about patient's chromosomes are evaluated and problems investigated. As we understand specialist do more work they can handle, so as engineers we should help them and government do special automations [1]. Diagnosis of heart diseases is done only by doctors today. With artificial decision making systems in the field of health information, this burden on physicians is partially removed. Although artificial decision support systems do not provide 100% reliable results, such studies are

important because they are informative and stimulating to the health personnel. At the same time, false medical interpretations and diagnoses given by doctors can produce terrible consequences. Decision support systems make it possible to re-evaluate medical diagnoses at this point. When examined from the perspective of computer and statistical science, the health sector can often be described as data-rich but lacking knowledge. It is obvious that there are some reasonable huge records available within the healthcare world. Reasonable methods of extracting are not used enough to discover hidden information and relationships within the data.
In recent years, Artificial Intelligence techniques have been inserted to various fields in health computing. Information discovery and data mining can be applied to many sectors and businesses. Valuable information can be identified through the data searching techniques in the health system. Healthcare applications like medical decision support systems are increasing. The use of artificial intelligence-based decision support systems is also becoming widespread to help physicians make diagnoses and treatments and prevent human error. Its chief science and technology officer, Dr. Timor explained to the TV programs that ai program they generated cut costs by over 13 billion dollars. Artificial Intelligence could improve the National Health Service's. Near 3 billion dollars wasted on pathology and gov. can reduce fifty % [2]. Cardiac problems are generally ends with mortality. Over 17 million deaths in a year, In 2030 it will increse 23.6 million. Scientists see that a heart patient dies every one minute over the World. Expenses of patients are over 320 billion dollars. It combines health expenses and lost efficiency. Actually 6 % of youngs, 48 % women of and 46 % men [3].

If we explain the hypothesis on the following issues:

Heart Diseases, Heart Crisis Different disease types can be detected quickly and accurately with ANN. They help decision support in making decisions.SVM and ANN give results at different speeds and precision to ingest data sets in different areas.The CAIM decomposition intervenes as a factor in speed and feature detection. The studies performed for the diagnosis of heart disease using the Statlog (Heart) Data Set can be listed as follows:

Duch et al. [4] used k-NN, k-NN via Manhattan, FSM, SSV algorithms. The max accuracy on Statlog heart dataset 85.6%. Sahan et al. [5] informs a system named Attribute Weighted Artificial Immune System (AWAIS) to reduce diverse in attributes that is used network-based Artificial Immune Systems (AISs). The correctness was 82.59 % with k-fold cross-validation method. Ozsen and Gunes [6] 3 distance criteria which are Euclidean, Manhattan, and hybrid similarity measure on a simple AIS for the classification of Statlog Heart dataset. The correctness was 83.95% with k-fold cross-validation method. Polat and Gunes [7] explained new feature selection method named kernel F-score feature selection (KFFS) used as pre-processing for classification of medical data-sets. Max correctness on this dataset 83.70 percent were completed by Combining of RBF kernel F-score fs and LS-SVM classifier. Kahramanli with Allahverdi [8]explained a hybrid NN's and FNN and achieved accuracy values 86.8 %. Ozsen et al. [6]Introduced a kernel-based AIS to tolerate this error by providing a nonlinear solution by converting of distance calculations in the colonal selection models of classical AIS to kernel space. This technique reached classification correctness with 5-fold cross-validation of 85.93 percent for this dataset. Subbulakshmi et al. [9]explained learning algorithm for (SLFNs) named Extreme Learning Machine (ELM). Karabulut E.M et al. [10] explained computational mean based on the Rotation Forest algorithm to predict Coronary Artery Disease. This method utilizes Artificial Neural Networks with the Levenberg-Marquardt back propagation algorithm as base classifiers of the Rotation Forest method. The obtained classification correctness was 91.20 % with 10-fold cross-validation method. The first aim was the creation of an original set of data from patients with heart attacks with a set of attributes that contain all the possible factors that can trigger a heart attack. The second is the construction of a fast and collective estimation mechanism with a high accuracy rate that is appropriate for medical practice. In our multidisciplinary project involving information and health sciences, we attempted to determine the individual risk of heart attack. An artificial clinical decision support system against deadly illness was developed by creating a real, authentic and reliable program using collective methods. With this system developed, the individual's possible heart attack can be predicted with a small error rate. According to the experimental results, individuals with higher risk percentage could be informed in advance and necessary measures were taken on time. We believe that this unique early warning system, which is proposed in the field of health information, is a first example but also has a separate prescription because it aims to protect human health and life.

II. PRELIMINARIES

Neural Networks

NN make decision like a "specialist" in any branch of science. This specialist has great popularity:

1. NN can learn adaptively: It can analyses system from input datasets and target datasets.
2. Individual-Automation: NN can make calculations in the real-time.
3. Rapidity: NN make calculations with several devices designed and manufactured for this purpose.
4. ReMaintanence: If damage occurs reducing performance some of network may be used for system work correctly.

ANN's process information system is inspired from nervous systems, brain process information. Artificial word differs neural networks from biologic systems. They are called easily (NN).

Information is processing immense connected neurons to handle tasks. Input units are aggregated in net. After some calculations output is ready for this input.

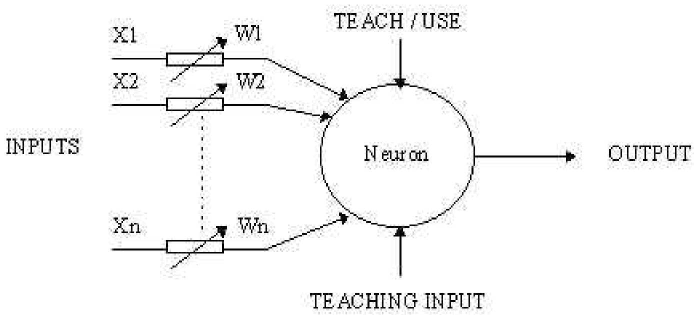

Figure.1. Informatıon processıng system[11].

NN's is able to get information. NN's, as us, learn by inputs. Learning can be done by processes exist between the neurons.

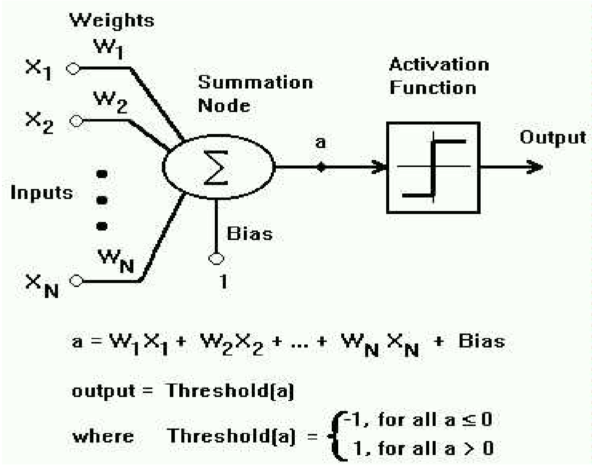

Figure.2. Actıvatıon process for nodes[11].

NN template has inputsets and outputsets but sometimes there is another part called hidden units. We can connect these units in different configs and NN architecture is configured. Activation function is deciding the output. We know two different ANN templates:

1. Feed-forward NN means one way only; from input set to output. No backloop.

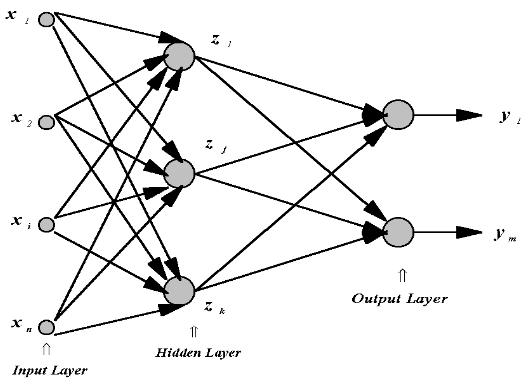

Figure.3. Backlooop networks calculates both dırectıons. They are not statıc. Values changes dynamıcally [12].

Hidden layer make nets more reasonable than plain perceptrons. Two known activation functions: sigmoid and threshold.

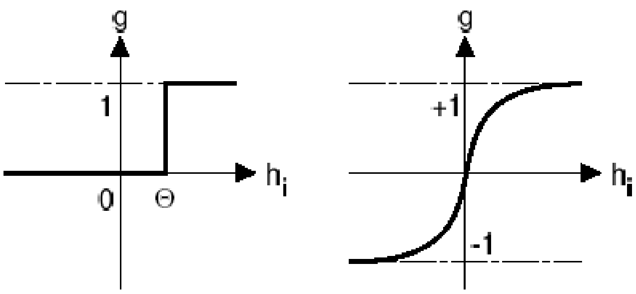

Figure.4. Threshold (a) and sigmoid (b) activation functions. [11].

Step is a linear aggregation of inputsets and if θ is reached neuron activates[13]. Sigmoid is smooth than step. Low input value is 0. It starts rising and after a time it saturates then passes threshold.

Support Vector Machine

SVMs is based on a hyperplane that divides data into its classes. When, dataset is not separable, SVMs uses kernel function transforms data into dividable. SVMs can be explicitly measured. SVMs are accepted to be useful for practical problems [14]. Datasets are seperated into logic sets to use for problems. [13]

n-dimension template x has n points,
x= (x1, x2, …, xn), (xi ϵ R for i = 1, 2, …, n)

All templates x-j registered to a set $y_j \in \{-1, +1\}$.
Training-sets T of m templates are with their class-sets,
T= {(x1, y1), (x2, y2), …, (xm, ym)}

think a point space S, in where templates x included (x1, x2, …, xm ϵ S),
Hyper-plane in S may be shown like:

$$\{x \in S \mid w \bullet x + b = 0\},\ w \in S, b \in R$$

The point product $w□x$ is defined by:

$$w \bullet x = \sum_{i=1}^{n} w_i x_i \qquad (1)$$

As seen in figüre the classifier correctly classifies all of the training patterns. Two different regions, for +1 function is w*x+b>0 and the others is w*x+b<0 are defined by this hyperplane.

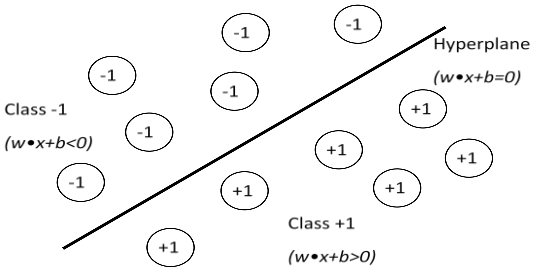

Figure 5 Hyperlane [15]

SVM is prepared to detect member-ship after the training process is completed. New patterns could be different from the ones used in training. The equation to determine the class of a pattern xk:

$$class(x_k) = \begin{cases} +1\ if\ \ w \bullet x_k + b > 0 \\ -1\ if\ \ w \bullet x_k + b < 0 \end{cases} \qquad (2)$$

SVMs is used for supervised learning. Codes starts against a dataset all vectors in the class arbitrarily labelled. Then calculations occur. Labels are changed if needed. To improve correctness changes are done [15].

CAIM(Class Attributte Interdependence Maximization)

CAIM as we know calculate numerical attributes statistically and make them groups. These groups then reevaluated in its weights. Like calculating average of groups. The group is labelled with that number. The problem of extracting wise product if non-definite attributes needed, discretization converts them to classes. CAIM is to maximize class dependence and create minimum count of intervals. The best classification correctness was developed. CAIM surely has minimum count of intervals and the maximum attribute dependency[16]. Some researches move one step forward and generated a programme for maximization. Can be used for preprocessing while extracting data. Ameva is one of the CAIM examples. It doesn't allow user to address number of intervals. Genetic problems have been classified with small differences in output but run time was longer [16]. The most problem about future is uncertainty. To extract valuable data known mining technics are recoded. We refer to solve problem with quanta matrix of uncertain attributes. They are used for class-attribute interdependency [17].

Table.1.Shows matrix table that is used in calculations of CAIM discretization.

Class	Interval			Class Total
	$[d_o, d_1]$	$[d_{r-1}, d_r]$	$[d_{n-1}, d_n]$	
C_1	q_{11}	q_{1r}	q_{1n}	M_{1+}
C_i	q_{i1}	q_{ir}	q_{in}	M_{i+}
C_s	q_{s1}	q_{sr}	q_{sn}	M_{s+}
Interval Total	M_{+1}	M_{+r}	M_{+n}	M

CAIM algorithm has many features like fast and efficient, supervised discretization and named data. Maximization interdependence between classes is its prior job and it generates intervals for classes. CAIM algorithm generates the smallest number of intervals for a non-definite attribute. It improves correctness when used before learning algorithm. I choses automatically intervals. Its velocity is faster than many other algorithms. It uses top-down approach. The algorithm does not guarantee finding global maximum. O (M log(M)). It starts with a class and divides it to boundaries that correspond to the highest values of CAIM criterion. Algorithm explains class count should be equal to number of intervals. The algorithm says each interval contains values grouped with a single class label. The squared max is scaled by M+r to reduce negative influence of the other classes. Aggregation is divided with n to Show number of intervals.

$$CAIM(C, D\backslash F) = \frac{\sum_{r=1}^{n} \frac{max_r^2}{M_{+r}}}{n} \qquad (3)$$

Where: N is the interval number

R moves from 1 to n maxr is max value in q(ir) (max in the r. column of the quanta matrix) M+r is the total number of continuous values from dr-1 to dr

Performance Evaluation

Confusion matrix, classification accuracy, analysis of specificity and sensitivity, k-fold cross-validation used in the system for performance evaluation and validation. Mathematical formulas and detailed explanations are given in the studies of Yilmaz and Inan et al [12].

III. DEVELOPING NEW DISEASE PREDICTION SYSTEM

Our project is about the development a medical decision-making system for predicting cardiac disorder risks for heart attacks and strokes. For this purpose, we searched for health records that will give answers for our targets. UCI [20] met our credentials. Cardiac disorder datasets are gathered from California Irvine University. Because they have various datasets for specific purposes. Many scientists work and worked on it. And you can control the results because you can download them to anywhere so as it public. After CAIM discreet maximization interdependency of attributes is being done we used these attributes with normalization. CAIM converts values interval classes. Minimum interval count is equal to class count. Tables gathered from UCI were normalized. When we normalize attributes contains numeric values, we converted them to specific rank contains [0, 1] values. The next step we passed was Neural Network and SVM steps. We take CAIM results to NN's and SVM separately. In first study we found NN's score. And second we found SVM score. We understood that 1. one gave better result than second. Second study's accuracy was 86.67% and First's was 87.78%.

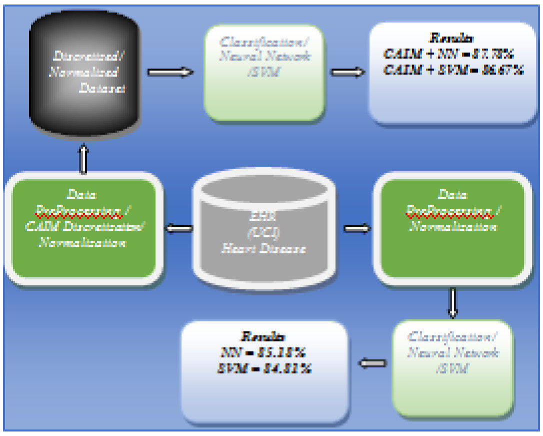

Figure .6. Block Diagram Of The System

We see above that the Project working scheme. If you look detail you see discretization indicated CAIM algorithm. After discretization is done NN' start to process. And we see its flow also UCI database has many kind of heart datasets. And we chose statlog. 14th column says yes or no to us to have a disorder risk in many ways. Algorithms to solve prediction of disorders attracted many researchers. Before many years ago, Medical prediction systems was based on manual inputs entered to computer systems. It was taking much time and medical person was deciding the information. To help these problems, mining, NN and machine learning techniques are constructed. We come up with a solution to add something more.

Table.2. Summary of heart disease attributes

Attribute	Description	Value Description
patient-age	patient-Age	numerical
patient-sex	patient-Sex	1.0 if Male; 0.0 if female
patient-cp	patient-Chest pain type	1.0 typical angina 2.0 atypical angina 3.0 non-anginal pain 4.0 asymptomatic
patient-trestbps	patient-Resting systolic blood-pressure (mmHg)	Numerical
patient-chol	patient-Serum cholesterol (mg/dl)	Numerical
patient-fbs	patient-Fasting blood-sugar over 120 mg/dl	1.0 if yes 0.0 if no
patient-restecg	patient-Resting electrocardiographic results:	0.0 normal 1.0 having ST-T wave abnormality 2.0 LV hypertrophy
patient-thalach	patient-Maxi heart-rate achieved	Numerical
patient-exang	patient-Exercise induced angina?	1.0 if yes 0.0 if no
patient-oldpeak	patient-ST depression induced by exercise relative to rest	Numerical
patient-slope	patient-The slope of the peak exercise ST segment	1.0 upslope 2.0 flatter 3.0 downslope
patient-ca	patient-Number of major vessels colored by fluoroscopy	Numeric
patient-thal	Exercise thallium scintigraphic defects	3.0 normal 6.0 fixed defect 7.0 reversible defect
num	Diagnosis of heart disease (angiographic disease status/ presence of coronary artery disease (CAD))	0.0 if less or equal than 50% diameter narrowing in any majör vessel (CADno) 1 if more than 50% (CAD yes) 1.0

Table II shows summary of heart disease attributes Value description explains what the column includes. Numerical values are subjected to CAIM and Normalization.

Last column gives information about major vessel status. If its narrowing, then this number increases up to end 3.

Table.3. List Of Svm Classification Parameters

Parameters	Value
Method	SVM
Optimization algorithm	SMO
Validation method	k-fold cross-validation (10-fold CV)
kN	500
Kernel Function	Linear
TolKKT	1.0000e-003
Maximum Iteration	15000
Kernel Cache Limit	5000
The initial value	Random

Table .4. Mlp Nn Architecture

Matlab Architecture Title	NN	CAIM+NN
Layer count	3	3
Input neuron count on the layer	13	42
Hidden-Layer	12	42
Output-Layer	1	1
Start values and bias values	Randomize	
Activation Functions	Tansig-function (for hidden layer) Tansig-function(for output layer)	
Learning functions	A gradient descent with momentum and adaptive learningrate backpropagation	
Goal	0.000001	

Table III shows SVM classification parameters and their values in the program. Value column gives information about parameters that can be changed. Table IV shows NN and CAIM+NN architecture parameters and their values. With CAIM we discrete numerical values.

IV.EXPERIMENTAL RESULTS AND DISCUSSION

A hybrid system using discretization and normalization for preprocessing step is proposed to increase success rates of classifiers that is making decision about whether patients who's records taken from UCI Statlog have a heart disease or not. This system increased ANN and SVM classifiers' success rates like seen in the Table VI.

So as this study is run in small intervals, system run time is decreased also. In Table V,VI classifiers raw results and developed system results like Sensitivity, Specifity, Positive Predictive Value and Negative Predictive Value are also given.

K-Fold cross validation is used for classifiers' reability. It is compared with same dataset results being done in the literature in Table VII. Results acquired are seen that our results are better most of them. Below we tried to explain our algorithm and other researchers' methods to make a comparison.

Table.5. Performance Of Svm Classification For The Statlog Heart Disease Dataset

Performance Criteria	SVM	CAIM +SVM
Accuracy (%)	84.81	86.66
Sensitivity (%)	80.61	87.05
Specificity (%)	88.37	86.64
Positive predictive value (%)	85.40	85.14
Negative predictive value (%)	84.29	89.46

Table V shows SVM and CAIM + SVM classification performance results for Statlog Heart Disease.

Table.6.Performance of Nn Classfication for the Statlog Heart Disease Dataset

Performance Criteria	NN	CAIM +NN
Accuracy (%)	85.18	87.78
Sensitivity (%)	88.31	90.76
Specificity (%)	83.24	82.78
Positive predictive value (%)	85.29	87
Negative predictive value (%)	84.50	88.51

Table VI shows NN and CAIM + NN classification performance results for Statlog Heart Disease.

Table.7. Comparison of literature [12]

Researcher	Algorithm	Correctness (%)
Duch [4].	k-NN, k=28.0, 7.0 features (10-fold CV)	84.6–85.6
	k-NN, k=28.0, Manhattan (10-fold CV)	82.2–83.4
	FSM, 27.0 fuzzy-rules	82
	SSV, 3.0 rules	80.2–83.4
Sahan et al. (2005) [5].	AWAIS (10-fold CV)	82.59
Ozsen and Gunes (2008) [6].	AIS algorithm with Hybrid similarity measure (10-fold CV)	83.95
Kahramanli and Allahverdi (2008) [8].	Hybrid-system using ANN and FNN (10-fold CV)	86.8
Ozsen et al. [6].	Kernel_Based AIS (5-fold CV)	85.93
Tian J. Et al. (2009) [18]	CC-EBFNN	82.45
Polat and Gunes (2009) [7].	LS-SVM classifier without feature selection (train: 50.0 %- test: 50.0 %)	80
	LM NN's without feature selection (Train: 50. %- test: 50.0 %)	71.11
	Combining of F-score feature selection and LS-SVM classifier (Train: 50.0 %- test: 50.0 %)	77.78
	Combining of F-score feature selection and NN's	77.61

	(Train: 50.0 %- test: 50.0 %)	
	Combining of linear kernel F-score feature selection and LS-SVM Classifier (train: 50.0 %- test: 50.0 %)	80
	Combining of linear kernel F-score feature selection and NN's (train: 50.0 %- test: 50.0 %	83.7
	Combining of RBF kernel F-score feature selection and LS-SVM Classifier (train: 50.0 %- test: 50.0 %)	80
	Combining of linear kernel F-score feature selection and NN's (train: 50.0 %- test: 50.0 %)	76.3
Subbulakshmi et al. (2012) [9].	ELM	87.5
Karabulut E.M et al. [10]. (2012)	Rotation Forest, Levenberg-Marquardt (10-fold CV)	91.2
Ahmad F. Et al. [19]. (2013)	Improved Genetic Al (train: 75.0 %- test: 25.0 %) Average of 10 runs	86.3
Our project	CAIM + ANN	87.78
Our project	ANN	85.18
Our project	CAIM + SVM	86.67

V. CONCLUSION

To help healtcare system -general practioners, heart disease sufferers- we tried to detect the risk of heart attack by bringing together technologies such as software algorithms, artificial intelligence, medical decision support mechanisms, discretization algorithms, normalization and support vector machines. Giving a skill to a general practitioner in a rural region where there is not a specialist doctor is one of the search aim that we tried to do and also we tried to predict some kind of disease here heart stroke or attack without human decision. To generate a forecasting program, we used statistical calculations and artificial neural networks, algorithms for iteration, normalization, discretization and systems like decision support and expert constituted our infrastructure. The system was created by combining normalization, CAIM, ANN and SVM algorithms. The accuracy of the proposed system is 87.78% by output that was generated by normalized, discreeted and classified values. The method used in the proposed system is compared with the other studies done with the same data set in the literature. The results have been seen as promising for future. In this project, a medical decision system working with NN's and SVM were proposed and by adding hybrid system (CAIM discretization and normalization) the accuracy of system was increased. Firstly we tried to find solutions via NN's (85.18%), SVM (84.81). Then we added them CAIM to see difference that discretization adds to. Normalization also. So we achieved 4 different situations. Situation one was measuring CAIM plus NN (87.78%). Situation two measures CAIM + SVM (86.67%). Situation three was measuring NN and last was SVM. Doing that we measured CAIM + Normalization when used with NN's and SVM. K-fold cross-validation was used for reliability of result's. The results were compared with literature. Developed MDSS (Medical Decision Support System) yielded better results than the previously prepared neural network and SVM systems. It was observed that our results were promising.

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