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Şengül Doğan
İbrahim Türkoğlu
Mustafa Yavuzkır
University of Firat
vsenguldogan@hotmail.com
Elazig-Turkiye

HEART ATTACK DETECTION FROM CARDIAC ENZYMES BY USING DECISION TREES

ABSTRACT

In this study A Decision Support System has been projected from the biochemistry blood parameters which will be very helpful for and will make everything easier for the physicians in the diagnosis of Myocardial Infarction. Based on pattern recognition process, the system operation is achieved via the decision trees structure which is related as one of the data mining techniques. The basic characteristic of the cardiac enzymes that is CK, CKMB, LDH, AST and ALT enzymes are used in the process of entering the system and finally MI(+) and MI(-) results have been evaluated at the end of this process. Data of 61 patients are evaluated in the projected system. The results of the decision support system have completely matched with those of the physicians decisions.

Keywords: Pattern Recognition, Data Mining, Decision Tree, Cardiac Enzymes, Expert Systems.

KARAR AĞACI YÖNTEMİNİ KULLANARAK KARDİYAK ENZİMLERİ İLE KALP KRİZİ TEŞHİSİ

ÖZET

Bu çalışmada, biyokimya kan test sonuçlarından Miyokart Infarktüsü teşhisinde, hekime yardımcı olacak ve kolaylık sağlayacak bir karar destek sistemi tasarlanmıştır. Örüntü tanıma süreci esas alınmış olup, sistemin işleyişi veri madenciliği tekniklerinden olan karar ağaçları yapısı ile sağlanmaktadır. Sisteme giriş olarak, kardiyak enzimlerinden temel belirleyiciler olan CK, CK-MB, LDH, AST, ALT enzimleri kullanılarak, çıkış olarak ta MI(+) ve MI(-) değerlendirmelerin de bulunulmuştur. Tasarlanan sistemde 61 hasta verisi değerlendirilmiştir. Karar destek sisteminin sonuçları, doktorun verdiği kararlarla tamamen örtüşmüştür.

Anahtar Kelimeler: Örüntü Tanıma, Veri Madenciliği, Karar Ağacı, Kardiyak Enzimler, Uzman Sistemler.

1. INTRODUCTION (GİRİŞ)

Myocardial Infarction (MI) is a term which is used for defining the necrosis in the heart muscle due to the lack of the oxygen need of myocard which can not be supplied by the coroneries. MI is still one of the most important illnesses in the world that causes mortality and morbidity. MI diagnosis is based on the clinical symptoms, changes of ECG and the increase of cardiac enzymes in serum levels. By determining the increase in the serum values, MI diagnosis is confirmed. Such enzymes are defined as the diagnostic laboratory characteristics of MI and as the cardiac enzymes [1]. Biochemistry laboratory test results are used in order to determine the cardiac enzymes. Clinical Biochemistry is a kind of peculiar medical laboratory science which includes the determination of biochemical mechanisms in healty and illness process, the differentiating determination and the choice of the tests and techniques in the determination process of prognosis and evaluation of these results and clinicians' consultation [2]. The increasing enzyme level is also helpful for the timing of infraction. The enzymes taken into consideration in MI diagnosis are CK, CKMB, LDH, AST, ALT, Myoglobin and Troponin [3, 4, 5, and 6].

These enzymes form great data stacks when used in each person's diagnosis. Also, as these kinds of researches in the biology and medical science world increase, this will cause the increase in different kinds of data related with the real-life cases [7]. It became quite difficult for people to be able to comprehend and change hundreds of characteristics and thousands of images into meaningful knowledge in modern medical science [8, 9]. DNA [10, 11] and protein synthesis [12], biological state measurements [13], graphs [14] and enzymes [7] are some of the main types of data which are still being used. As the data increased it became quite a boring and difficult work for the medical science experts to prepare a guide that will be used in the processes of reading, simplifying, classifying the findings and making a decision at the end. Also a lot of findings hidden in these data have remained as the data stack in this way. It is necessary to get these data automatic in order to obtain useful information. Getting information from the databases or the data mining is the kind of method mostly used for solving these kinds of problems [15]. Data mining is used for both getting the information related with the text and the information of the image data of an individual patient and then for matching each patient's entry [16]. In this context data mining has been applied so successsfully in many fields of medical science [15, 16, and 17]. For instance, there are a lot of work that can be seen in the literature related with discovering certain rules in the diagnosis and treatment of acute ailments; applying the determined rules and making complementary data mining for defining the enlargement states of the working procedures of the refined, shared, organized and produced information in the system [18] and also there are some works related with projecting a Data Acquiring System for the baby deaths due to the Hypoplastic Left Heart Syndrome and making quick and true guesses using the acquired data [19].

Data mining is the work of achieving the information that enables us to find the relations among the great numbers of data which will be very helpful for making guesses about the future by using a computer programme. That is, the aimed information is obtained by processing the data. Data mining is used in many fields such as biomedicine, gene functions, data analysis of DNA arrangement pattern, diagnosis of illnesses, retail data, telecommunication industry, guesses about selling, financial analysis and astronomy [20]. For instance, some standart softwares used in a medical diagnosis system were problematic because of the unsystematic data, the abscence of control, the usage of too many various kinds, being unable to make a consistent and systematic analysis on databases, comparing the examples and determining the critical differences. So, the physicians were in the opinion that these softwares were short of many characteristics. In this context, data mining which makes it possible to make a basic analysis on the graphs related with both the digital parameters and morphemes by the help of an expert information system and which stores the processes, administers the necessary information and also which includes a very useful construction such as a reference for decision, took an active position. Data mining and techniques are also accepted in the medical science world because they make everything easier for the experts and provides a necessary and important help for the practitioners [21]. In fact data mining is evaluated as a part of the information discovery process both in medical science and in the other fields [22]. Data mining stages are presented in Figure 1 [23].

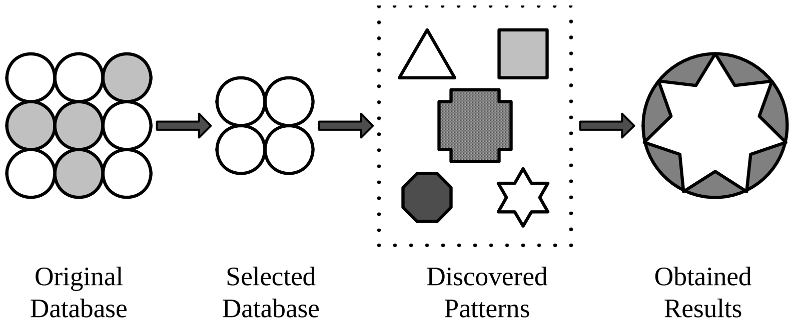

Figure 1. Data mining processes
(Şekil 1. Veri madenciliği süreci)

Data mining has an interaction with the user and the database. Interesting data patterns are showed to the user. And also, they can be saved in the database if wanted. According to this, data mining goes on till the hidden data patterns are found [24].

Firstly the necessary data are taken, classified and then processed while obtaining meaningful information from the databases. It is an important problem to be able to save the state of a patient and to predict the characteristic of the data such as all the laboratory test results, findings and signals of all the patients. These points are also problems in machine learning and data mining which works in many fields such as classification and problem detection [9]. Classification in data mining is used for an automatic definition of the interesting object in great data and for the information discovery in the applications including the classification of the trend in the market [25]. There are a lot of methods used for classifying these data. In data mining the decision trees among these techniques, which have the characteristics of making guesses and defining, have the most common usage in the classification models because of the following reasons: [26]

- Inexpensiveness of the organization,
- Easiness in interpretation,
- Their possibility of being easily integrated with the database systems,
- More reliability.

In these works, data stores are known as the clinical stores in medical field [7]. Data warehouses in medicine field are called clinical warehouse too. Then, those clinical stores containing biological, clinical and administrating data unit the patients information. Thus, the possibility of the usage of the systems related with the patient is improved [27].

2. RESEARCH SIGNIFICATION (ÇALIŞMANIN ÖNEMİ)

In this study, a decision support system while will be helpful for the diagnosis of MI is improved to be used for the aim of classifying the decision tree construction from the data mining techniques. Cardiac enzyme parameters from biochemistry data were used for application and 61 patient' data have been evaluated successfully.

3. THEORETICAL VIEW (TEORİK BAKIŞ)

In this part, the informations related with the easier conception of the decision support system's construction in MI diagnosis is introduced in the shape of sub-classifications.

3.1. Pattern Recognition (Örüntü Tanıma)

Pattern recognition can be divided into a sequence of stages, starting with feature extraction from the occurring patterns, which is the conversion of patterns to features that are regarded as a condensed representation, ideally containing all the necessary information. In the next stage, the feature selection step, a smaller number of meaningful features that best represent the given pattern without redundancy is identified. Finally, classification is carried out: a specific pattern is assigned to a specific class according to its characteristic features, selected for it. This general abstract model, which is demonstrated in Figure 2, allows a broad variety of different realizations and implementations [28]. Applying this terminology to the medical diagnostic process, the patterns can be identified, for example, as particular, formalized symptoms, recorded signals, or a set of images of a patient. The classes obtained represent the variety of different possible diagnoses or diagnostic statements [29].

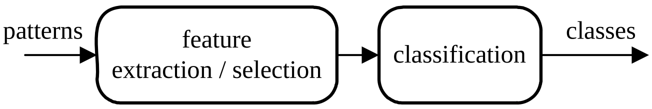

Figure 2. Pattern recognition system
(Şekil 2. Örüntü tanıma sistemi)

3.2. Cardiac Enzymes (Kardiyak Enzimler)

The classic World Health Organization (WHO) criteria for the diagnosis of AMI (acute myocardial infarction) require that at least two of the level following three elements be present. There is considerable variability in the pattern of presentation of AMI with respect to these three elements, as exemplified by the following statistics. ST segment elevatining and Q waves on the ECG, two features that are highly indicative of AMI, are seen in only about half of AMI cases on presentation. Approximately one third of patients with AMI do not present with classic chest pain, and the event would go unrecognized unless an ECG were recorded fortuitously in temporal proximity to the infarction or permanent pathological Q waves were are seen on later tracings. Moreover, in the majority of patients, clinicians must obtain serum cardiac enzyme measurements at periodic intervals to either establish or exclude the diagnosis of AMI; such measurements may also be useful for a rough quantitation of the size of infarction.

Creatine Kinase (CK): Serum CK activity exceeds the normal range within 4 to 8 hours after the onset of AMI and declines to normal within 2 to 3 days. Altough the peak CK occurs on average at about 24 hours, peak levels occur earlier in patients who have had reperfusion as a result of the administration of thrombolytic therapy or mechanical recanalization. Because the timeactivity curve of serum CK is influenced by reperfusion interferes with estimation of infarct size by enzyme analysis. Although elevation of the serum CK is a sensitive enzymatic detector of AMI that is routinely available in most hospitals, important drawbacks include false-positive results in patients with muscle disease, alcohol intoxication, diabetes mellitus, skeletal muscle trauma, vigorous exercise, convulsions, intramuscular injections, thoracic outlet syndrome, and pulmonary embolism.

CK Isoenzymes: Three isoenzymes of CK (MM, BB, and MB) have been identified by electrophoresis. Extracts of brain and kidney contain predominantly the BB isoenzyme, skeletal muscle contains principally MM but does contain some MB (1 to 3 percent), and both MM and MB isoenzymes are present in cardiac muscle. The MB isoenzymes of CK may also be present in minor quantities in the small intestine, tongue, diaphragm, uterus, and prostate. Strenuous exercise, particularly in trained long-distance runners of professional athletes, may cause elevation of both total CK and CK-MB. Because CK-MB can be detected in the blood of healthy subject, the cutoff value for abnormal elevation of CK-MB is usually set a few units above the end of the reference range for a given laboratory. Despite the fact that small quantities of CK-MB isoenzyme are found in tissues other than the heart, elevated levels of CK-MB may be considered, for practical purposes, to be the result of AMI.

Earlier CK-MB assay methods that were in common use included radioimmunoassay and agarose gel electrophoresis techniques; these have now been largely supplanted by highly sensitive and specific enzyme immunoassays that use monoclonal antibodies directed aganist CK-MB. Massassays report results in nanograms per milliliter rather than units per milliliter and have been confirmed to be more accurate than CK-MB activity assays, especially in patients presenting within 4 hours of onset of AMI.

In addition to AMI secondary to coronary obstruction, other forms of injury to cardiac muscle-such as those resulting from myocarditis, trauma, cardiac catheterization, shock and cardiac surgery-may also produce elevated serum CK-MB levels. These latter causes of elevation of serum CK-MB values can usually be readily distinguished from AMI by the clinical setting [30].

AST, ALT: The AST assay is not specific for cardiac muscle. Hepatocellular damage can also cause a considerable AST rise. In the specimens taken at 19 h and 45 h alanine aminotransferase activity (ALT) was measured to check for a possible hepatic component. One patient in the transmural infarction group showed a high AST level as well as a largely increased ALT activity, indicating coinciding hepatocellular damage probably caused by heart failure [31].

LDH: The activity of this enzyme exceeds the normal range by 24 to 48 hours after the onset of AMI reaches a peak 3 to 6 days after the onset of pain, and returns to normal levels 8 to 14 days after the infarction. LDH comprises five isoenzymes, which are numbered in the order of the rapidity of their migration toward the anode of an electrophoretic field. LDH_1 moves most rapidly, whereas LDH_5 is the slowest. Fractionation of the serum LDH into its five isoenzymes increases diagnostic accuracy because the heart contains principally

LDH_1. However, LDH isoenzyme analysis for the diagnosis of AMI is no longer recommended because it has been superseded by newer, more cardiac-specific late enzymes such as cTnT or cTnI [30].

3.3. Decision Trees (Karar Ağaçları)

After the data are created in decision trees, the rules can be written down on the tree from root to the leaf (If-Then rules). Getting decision in this way provides the confirmation of the result of the work of data minig. These rules can be checked in terms of application by showing them to an expert whether they are meaningful or not [32]. The decision trees are used in the analysis and applications of classifying various cases into low-mid or high risk groups; creating rules in order to predict the future events; definition of the relations of the certain sub-groups; the unition of the categories and getting the most effective decisions by the help of the medical observation [29 and 33]. Structure of rule extraction is given in table 1 [34].

Table 1. Rule extraction
(Tablo 1. Kural çıkarımı)

If (rule1) *then* (decision1) *elseif* (rule2) *then* (decision2) … … rule = <a1> *and* … and <an> decision = Ψ, Ψ∈ [$\Omega_1 \ldots . \Omega_m$]

Here each one of decision class's parts that will be taken in rules are represented with Ω and the result that will be arrived from that class parts are represented with Ψ. The preparation of such a decision list constitutes an important step in a medical application and a decision tree can be created easily according to these rules [15]. A decision tree algoritm that is created according to these rules constitutes a decision tree in the context of information obtainment [35].

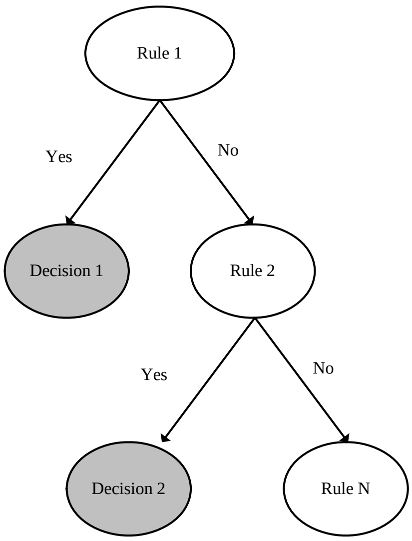

Figure 3. The decision tree structure
(Şekil 3. Karar ağacı yapısı)

4. DEVELOPED METHOD (GELİŞTİRİLEN METOT)

The most common and main tests that help the physicians decide on a diagnosis are ECG and biochemistry tests which are mostly successful in diagnosing. An MI diagnosis can be obtained by controlling the muscle enzyme parameters, in other words the cardiac enzymes which were taken into consideration for the MI diagnosis in biochemestry test results. The construction of the improved decision support system is showed in Figure 4 based upon the pattern recognition given in part 2.1. The functions of system are constituted of these following steps:

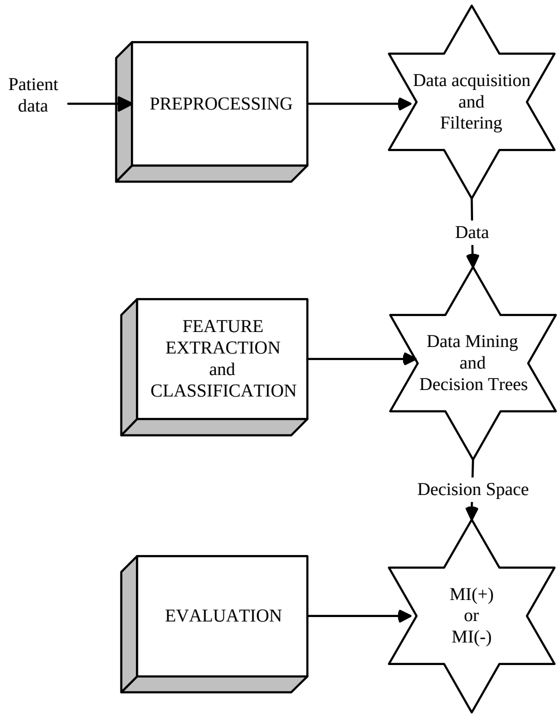

Figure 4. The algorithm of decision support system
(Şekil 4. Karar destek sistemi algoritması)

Step–1: Pre-processing

Collecting the data is the step in which the ones those are proper for the goal are choosen. The necessary data were obtained by collecting the biochemistry test results of the patients applied for the cardiology service and by analyzing the ones related with the muscle enzymes with the direction of the physicians. The database was created by choosing the test results of the MI suspected-ill from the data collected.

Step–2: Feature Extraction and Classification

This is the most important step of decision tree based decision support system which was developed for processing the data in the collected database. The data collected are being processed in this stage. For this, the rules underlined in table2 and determined according to the physician’s knowledge and then the decision tree in figure 5 was obtained in relation with this knowledge.

Table 2. The rule base of proposed system
(Tablo 2. Önerilen sistemin kural yapısı)

Rules	Decision Tree Index
if (ck>= 195) *and* (ckmb>=25) *and* (ldh>=450) *and* (ast>=40) *and* (alt>=40) *then*	*(a)*
else if (ck>= 195) *and* (ckmb>=25) *and* (ldh>=450) *and* (ast>=40) *and* (alt<40) *then*	*(b)*
else if (ck>= 195) *and* (ckmb>=25) *and* (ldh>=450) *and* (ast<40) *and* (alt>=40) *then*	*(b)*
else if (ck>= 195) *and* (ckmb>=25) *and* (ldh>=450) *and* (ast<40) *and* (alt<40) *then*	*(c)*
else if (ck>= 195) *and* (ckmb>=25) *and* (ldh<450) *and* (ast>=40) *and* (alt>=40) *then*	*(d)*
else if (ck>= 195) *and* (ckmb>=25) *and* (ldh<450) *and* (ast<40) *and* (alt>=40) *then*	*(e)*
else if (ck>= 195) *and* (ckmb>=25) *and* (ldh<450) *and* (ast>=40) *and* (alt<40) *then*	*(e)*
Else if (ck>= 195) *and* (ckmb>=25) *and* (ldh<450) *and* (ast<40) *and* (alt<40) *then*	*(f)*
else if (ck>= 195) *and* (ckmb<25) *and* (ldh>=450) *and* (ast>=40) *and* (alt>=40) *then*	*(g)*
else if (ck>= 195) *and* (ckmb<25) *and* (ldh>=450) *and* (ast<40) *and* (alt>=40) *then*	*(h)*
else if (ck>= 195) *and* (ckmb<25) *and* (ldh>=450) *and* (ast>=40) *and* (alt<40) *then*	*(h)*
Else if (ck>= 195) *and* (ckmb<25) *and* (ldh>=450) *and* (ast<40) *and* (alt<40) *then*	*(i)*
else if (ck>= 195) *and* (ckmb<25) *and* (ldh<450) *and* (ast>=40) *and* (alt>=40) *then*	*(j)*
Else if (ck>= 195) *and* (ckmb<25) *and* (ldh<450) *and* (ast<40) *and* (alt>=40) *then*	*(k)*
Else if (ck>= 195) *and* (ckmb<25) *and* (ldh<450) *and* (ast>=40) *and* (alt<40) *then*	*(k)*
Else if (ck>= 195) *and* (ckmb<25) *and* (ldh<450) *and* (ast<40) *and* (alt<40) *then*	*(l)*
else if (ck< 195) *and* (ckmb>=25) *and* (ldh>=450) *and* (ast>=40) *and* (alt>=40) *then*	*(m)*
else if (ck< 195) *and* (ckmb>=25) *and* (ldh>=450) *and* (ast>=40) *and* (alt<40) *then*	*(n)*
else if (ck< 195) *and* (ckmb>=25) *and* (ldh>=450) *and* (ast<40) *and* (alt>=40) *then*	*(n)*
Else if (ck< 195) *and* (ckmb>=25) *and* (ldh>=450) *and* (ast<40) *and* (alt<40) *then*	*(o)*
else if (ck< 195) *and* (ckmb>=25) *and* (ldh<450) *and* (ast>=40) *and* (alt>=40) *then*	*(p)*
Else if (ck< 195) *and* (ckmb>=25) *and* (ldh<450) *and* (ast<40) *and* (alt>=40) *then*	*(q)*
Else if (ck< 195) *and* (ckmb>=25) *and* (ldh<450) *and* (ast>=40) *and* (alt<40) *then*	*(q)*
Else if (ck< 195) *and* (ckmb>=25) *and* (ldh<450) *and* (ast<40) *and* (alt<40) *then*	*(r)*
else if (ck< 195) *and* (ckmb<25) *and* (ldh>=450) *and* (ast>=40) *and* (alt>=40) *then*	*(s)*
else if (ck< 195) *and* (ckmb<25) *and* (ldh>=450) *and* (ast>=40) *and* (alt<40) *then*	*(t)*
else if (ck< 195) *and* (ckmb<25) *and* (ldh>=450) *and* (ast<40) *and* (alt>=40) *then*	*(t)*
else if (ck< 195) *and* (ckmb<25) *and* (ldh>=450) *and* (ast<40) *and* (alt<40) *then*	*(u)*
else if (ck< 195) *and* (ckmb<25) *and* (ldh<450) *and* (ast>=40) *and* (alt>=40) *then*	*(v)*
else if (ck< 195) *and* (ckmb<25) *and* (ldh<450) *and* (ast<40) *and* (alt>=40) *then*	*(w)*
else if (ck< 195) *and* (ckmb<25) *and* (ldh<450) *and* (ast>=40) *and* (alt<40) *then*	*(w)*
else if (ck< 195) *and* (ckmb<25) *and* (ldh<450) *and* (ast<40) *and* (alt<40) *then*	*(x)*

Among the enzymes given in the biochemistry test results the normal values of cardiac enzyme parameters are given in Table 3.

Table 3. The normal values of cardiac enzymes
(Tablo 3. Kardiyak enzimlerinin normal değerleri)

Enzymes	Normal values
CK	*24-195 U/L*
CKMB	*0-25 U/L*
AST	*5-40 U/L*
ALT	*5-40 U/L*
LDH	*220-450 U/L*

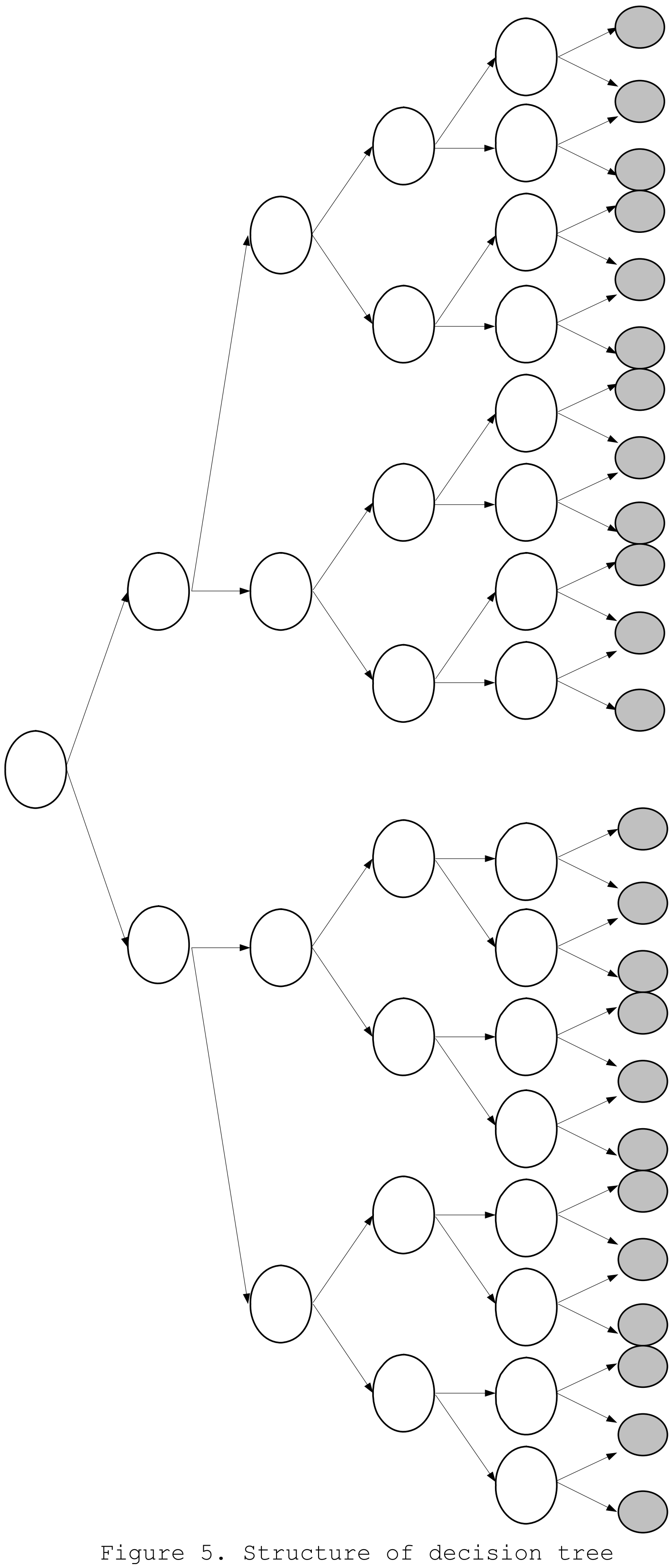

Figure 5. Structure of decision tree
(Şekil 5. Karar ağacının yapısı)

Step–3: Evaluation

In this step, the data obtained after the feature extraction and classification process are presented after the evaluation. The results reached to a, b, c, d, e, f, g, h, i, j leaves of the decision tree structure, (Figure 5) projected for this purpose, are evaluated with the MI(+) diagnosis and the results reached to the k, l, m, n, o, p, q, r, s, t, u, v, w, x leaves of the tree are evaluated directly as MI(-).

5. RESULTS (SONUÇLAR)

The developed decision support system is experienced on the biochemistry test results of the 61 patients. In the system MI(+) diagnosis was certain in 50 of the 61 patients and the other 11 were healthy. And we saw that these results have successfully matched with the physicians'. This success rate has clearly and undoubtfully showed the reliability and the effectiveness of the projected decision support system because of the perfect match between the physicians' decisions in the MI diagnosis and the results of the developed system.

Table 4. Performance of the decision support system
(Tablo 4. Karar destek sisteminin performansı)

	Myocardial Infarction	
	MI (+)	MI (-)
Total number of samples	50	11
Correct classification	50	11
Incorrect classification	---	---

6. DISCUSSIONS AND CONCLUSIONS (TARTIŞMA VE SONUÇLAR)

The increase in the knowledge obtained under the light of biomedical searches, the processes of reading, simplifying, classifying these findings and making a decision are being so complex day by day. These processes are automized after the data mining took a part in this field. It has considerably helped the medical experts and made it easier to prepare a guide. Also, a lot of findings hidden between the data mining and the data stacks obtained in these kinds of fields, has turned to be useful information in this way.

The advised system is based on pattern recognition on which so many clever diagnosis systems are constituted. There, the decision trees, which take an important part in data mining for the feature extracting and classification stage in the pattern recognition process, have been used. Thus, a decision support system is projected based on pattern recognition and the function of the system is based upon the data mining methods.

The developed decision support system will considerably be helpful for the expert physicians and practitioners for the interpretation of the illnesses. This system construction can also be used in the diagnosis of every illnesses in which the criteria having certain parameters can be controlled.

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