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Estimation of Anatolian Men's Helix, Tragus and Lobule Anatomical Points Using Artificial Neural Networks Pattern Completion

Farklı Yaş Gruplarından Oluşan 20 Yaş Üstü Anadolu Erkeklerinin Helix, Tragus ve Lobule Anatomik Noktalarının Yapay Sinir Ağlarının Örüntü Tamamlama Özelliği Kullanılarak Kestirimi

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Abstract: Measuring the physical differences and distinctive features of individuals with scientific techniques metrically is one of the important study topics of forensic identification and criminology. Ear is a limb frequently used in forensic identification studies due to its characteristic morphology. Geometrical morphometry is used in resurfacing studies and reconstructive surgery. Successful results with high accuracy can be obtained thanks to the application of artificial intelligence techniques as well as basic statistical methods in the examination of the relationships between the numerical data obtained by geometric morphometry techniques and the anatomical points. Artificial neural networks can produce high accuracy outputs for certain inputs defined by mathematically modeling the basic learning methods of the human brain. In addition, it is able to learn the solution of the specified problem without the need for the mathematical function existing between input and output variables and can update itself according to changing conditions. In this study, right ear photos of 450 male individuals, 150 individuals between the ages of 20-39, 150 individuals between the ages of 40-59 and 150 individuals over 60, were taken by the same photographer under identical conditions and arranged with the "image j" program. The coordinates of 11 anatomical points belonging to his right ears were obtained. 70% of these data obtained equally in every age range were applied to the artificial neural network model created with Matlab © program and used in the training of the network. The operation of the network was tested with 20% of the remaining data and the verification of the network was performed with the last 10% data. In the testing and verification processes of the designed network structure, the coordinates of 8 anatomical points were applied to the entrance of the network, and the coordinates of the Helix, Tragus and Lobule anatomical points were provided with a high accuracy and fast estimation by completing the pattern.

Structured Abstract: Geometric morphometry is used landmark that is predetermined and marked on the material to be used or the interpretation of the form and shapes of organisms using x, y coordinates. Today, it is a rapidly developing technique in terms of identity studies. Geometric Morphometry approaches use indirect methods of anthropometric measurements. It is impossible to taken from the individuals bodies' with anthropometric instruments like small-big calipers and anthropometry boards, but general or specific area photographs of individuals can provide datas that enabling anthropometric measurements to be taken in computer environment. External ear (auricula) photographs are one of them. Since these photos are used for

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indirect Anthropometry measurements, it can be accepted Geometric Morphometry as a new discipline that makes use of anthropometric measurements.

In this study, contains the right ear photographs of 450 male individuals living in Anatolia, 150 individuals between the ages of 20-39, 150 individuals between the ages of 40-59, and 150 individuals over the age of 60, taken by the same photographer under the same conditions and edited with the "image j" program. From these, the coordinates of 11 anatomical points of their right ears were obtained. 60% of the data obtained, being equal in all age ranges was used in the training of the network by applying it to the artificial neural network model created with the Matlab © program. With rest of the remaining data %20 network operation and with the rest of remaining data %20 verification of network tested. In testing and verification processes of the designed network structure, coordinates of 8 anatomical points were applied to the entrance of the network. By completing the pattern, Helix, Tragus and Lobule anatomical point coordinates were achieved by high accuracy and fast estimation.

Photographs of volunteers were taken with the Nikon D7000 professional camera used by the same person, at a distance of approximately five feet (1.54 meters) to provide the best depth. Avoid to reflecting light and due to the pictures can be easily extracted during the introduction of the programs, photograph setting to background is black, exposure time 1/60 sec, focal length 50 mm, 3.1 aperture, 24 bit deep, eight megapixel, 600 dpi resolution. Individuals are photographed in JPG format from the right. Photographs are taken by placing the camera on a water scale tripod.

Artificial neural networks method is created by modeling the learning ability of the human brain mathematically using different algorithms. In the application of artificial neural networks to a problem, firstly; the relation between input and output parameters that create the problem is learned. The most important advantage of artificial neural networks mentioned in the literature is the problem is that they can work without the need for a mathematical model and produce logical and high accuracy outputs. In addition, even though some data are missing or inaccurate, or the relationship between the input variables of the problem is far from linearity that it does not prevent the network from producing acceptable outputs. Because of these advantages, artificial neural networks are frequently used in the solution of multi-dimensional and complex problems

The fact that the data used in the training of the network in the applications of artificial neural networks includes all the parameters related to the problem space is one of the most important starting parameters for the solution of the problem. In order for artificial neural networks to learn the problem, the samples representing the problem must first be determined. In other words, it is not possible to train the artificial neural network or to produce a solution to the problem, when there are not enough samples to train the designed network. If all parameters representing the overall problem cannot be shown to the network in all aspects, successful results cannot be obtained. For this reason, creating and obtaining examples to be used in the education of the network is of great importance (Sağıroğlu et al., 2003). The equation given in Equation 5 is used for the preparation of the data and normalization of the network to a range that can be processed mathematically

Within the scope of this study, no feature selection method is applied to the attributes in the data set to obtain comparative results from decision tree algorithms; all attributes are taken into account in the formulation of the classification model. Data set does not contain any missing values. For this reason, the data set does not subjected to any pretreatment method. These and similar studies will be the main subjects of Forensic Sciences, especially Forensic IT and Forensic Anthropology in the future. Considering that multidisciplinary studies are more advanced today, we estimate that artificial neural networks will be used more widely in Forensic Sciences and Forensic Anthropology fields, and that criminal events will illuminate easier, faster and more economically.

Keywords: Anthropometry, Ear, Anatolian People, Identification, Artificial Neural Networks.

Öz: Bireylerin fiziksel farklılıkları ve ayırt edici özelliklerinin bilimsel tekniklerle metrik olarak ölçülmesi adli kimliklendirme ve krimonoloji alanının önemli çalışma konularından biridir. Kulak, karakteristik bir morfolojiye sahip olması nedeniyle adli kimliklendirme çalışmalarında sıklıkla kullanılan bir uzuvdur. Yeniden yüzlendirme çalışmalarında ve rekonstrüktüf cerrahide geometrik morfometri biliminden faydalanılmaktadır. Geometrik morfometri teknikleri ile elde edilen sayısal verilerin ve anatomik noktaların birbirleri ile olan ilişkilerinin incelenmesinde temel istatistik yöntemlerin yanı sıra yapay zekâ tekniklerinin uygulanması

sayesinde yüksek doğrulukta başarılı sonuçlar elde edilebilmektedir. Yapay sinir ağları, insan beyninin temel öğrenme yöntemlerinin matematiksel olarak modellenmesiyle tanımlanan belirli girişler için yüksek doğrulukta çıkışlar üretebilmektedir. Ayrıca giriş ve çıkış değişkenleri arasında var olan matematiksel fonksiyona ihtiyaç duymadan belirtilen problemin çözümünü öğrenebilmekte ve değişen koşullara göre kendini güncelleyebilmektedir. Bu çalışmada Anadolu'da yaşayan 20-39 yaş arasında 150 birey, 40-59 yaş arası 150 birey ve 60 yaş üstü 150 birey olmak üzere toplam 450 erkek bireyin sağ kulak fotoğrafları özdeş koşullarda aynı fotoğrafçı tarafından çekilerek "image j" programı ile düzenlenmiş ve sağ kulaklarına ait 11 anatomik noktanın koordinatları elde edilmiştir. Elde edilen bu verilerin her yaş aralığında eşit olmak üzere %70 lik kısmı Matlab © programı ile oluşturulan yapay sinir ağı modeline uygulanarak ağın eğitiminde kullanılmıştır. Geriye kalan verilerin %20 si ile ağın çalışması test edilmiş ve kalan son %10 luk veri ile de ağın doğrulanması gerçekleştirilmiştir. Tasarlanan ağ yapısının test ve doğrulama işlemlerinde ağın girişine 8 anatomik noktanın koordinatları uygulanmış ve Helix, Tragus ve Lobule anatomik noktalarının koordinatlarını örüntü tamamlama işlemi yaparak yüksek bir doğruluk ve hızla kestirimi sağlanmıştır.

Anahtar Kelimeler: Antropometri, Kulak, Anadolu İnsanı, Kimliklendirme, Yapay Sinir Ağları.

Introduction

Due to its geographical location, Anatolia has hosted to many different popülation in the historical durations. With transition to settled life that started with the Neolithic period, caused human communities to settle in many regions in Anatolia. Besides archaeological records from these areas, with examining of skeletal remains shows that both cultural features and understanding their physical characters. Examining Anatolian skeleton samples is very important for anthropological studies because of the rich diversity of people populations. In Physical Anthropology, which is the sub-discipline of Biological Anthropology, Geometric Morphometry studies can be examined on soft tissue (Özkoçak, 2018). Morphometry refers to a form including its quantative analyses, size and shape. With fine measurements of living beings intraspecific and interspecies comparison is possible (Özkoçak & Görgün, 2018; Özkoçak & Gültekin, 2017).

Geometric morphometry is used landmark that is predetermined and marked on the material to be used or the interpretation of the form and shapes of organisms using x, y coordinates. Today, it is a rapidly developing technique in terms of identity studies. Geometric Morphometry approaches use indirect methods of anthropometric measurements. It is impossible to taken from the individuals bodies' with anthropometric instruments like small-big calipers and anthropometry boards, but general or specific area photographs of individuals can provide datas that enabling anthropometric measurements to be taken in computer environment. External ear (auricula) photographs are one of them. Since these photos are used for indirect Anthropometry measurements, it can be accepted Geometric Morphometry as a new discipline that makes use of anthropometric measurements (Özkoçak & Görgün, 2018).

Artificial neural networks method is a mathematical modeling of the learning ability realized by the human brain by working with the central nerve system infrastructure. This model designed, basically with all the functions of the layered and parallel structure of the human brain composed of nerve cells obtained by trying to realize in the digital world. Therefore, artificial neural networks are the software creation of a roughly mathematical model of the human brain. Artificial neural networks have ability being able to establish a relationship between linear and nonlinear responsive inputs and outputs defined based on various parameters related to a system and completing the pattern. Artificial neural networks can able to be generalizing and they don't need to mathematical modeling of the relation between input and output, hence they are used in many applications (Öztemel, 2003; Sağıroğlu et al., 2003).

In this study, contains the right ear photographs of 450 male individuals living in Anatolia, 150 individuals between the ages of 20-39, 150 individuals between the ages of 40-59, and 150

individuals over the age of 60, taken by the same photographer under the same conditions and edited with the "image j" program. From these, the coordinates of 11 anatomical points of their right ears were obtained. 60% of the data obtained, being equal in all age ranges was used in the training of the network by applying it to the artificial neural network model created with the Matlab © program.

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The Structure of Human Ear

The auricle consists of 3 parts: helix-antihelial complex, conchal complex and lobulus auriculae. Due to its fixed position on the lateral side of the face, it is frequently used in identification studies in forensic anthropology, age, gender and race determination. Auricle's size is bigger than retina and iris besides easier recognition in the terms of its anatomical structure. All this provides a great advantage in the sex and age determination of individuals. The shape and size of the ear can be varies because of age, sex and ethnic origins. Ear appearance and symmetry contribution is very important in facial aesthetics and otoplasty surgeries. Therefore, before plastic surgeons change the shape of an ear, contributes greatly to the success of the operation to know the shape, size and proportions of healthy individuals (Özkoçak, 2018).

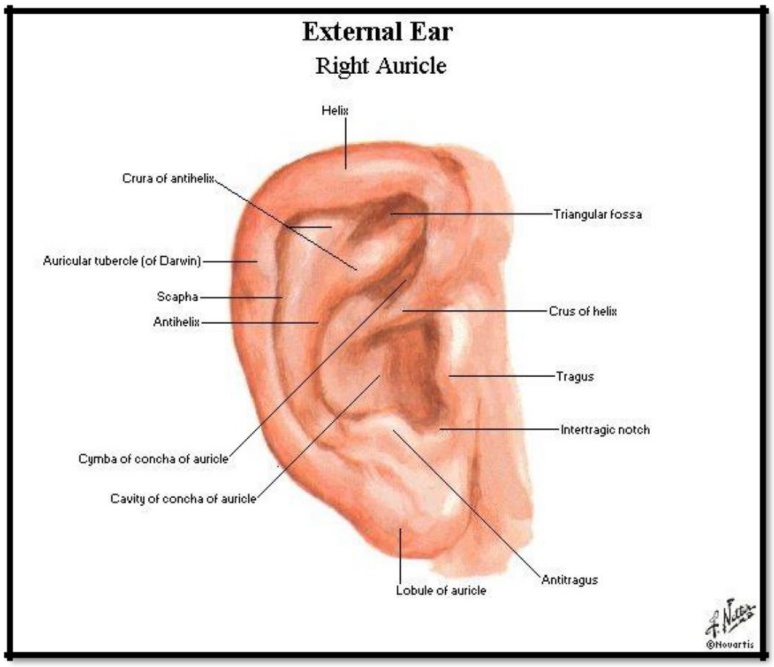


Figure 1 Right Ear Anatomical Landmarks

In the data obtained from the right ears of individuals, 11 landmark methods, which are given in Figure-1 and frequently used in the literature, are used. These landmarks are indicated in Table 1. Quarterly measurements and angle of ear length with reference planes of landmarks are given in Figure-2.

Table 1: Right Ear Landmark Locations (Özkoçak & Özdemir, 2018; Özdemir & Özkoçak, 2018)

Landmark	**Location**
Helix Rim	The pronounced edge spiral of the Auricula.
Fossa Triangularis	The triangle area between two Crus in antihelix.
Crus Antihelicis	Crus overhang on the tragus.
Helix	The outermost spiral of the outer ear.
Crus Helicis	The innermost helix of the outer ear.
Cavum Conchae	The protrusion located on the Antitragus in the deepest part of the Auricula.
Antihelix	Cartilage curved rim on scapha.
Scapha	Across the tragus, inner edge of outer ear facing hole
Tragus	Outward protrusion of the outer ear
Antitragus	Outward facing part on Cavum Conchae.
Lobule	Soft breast part consisting of aerolar and adipose connective tissues with elasticity of the ear.

In the study, a phenotypic variable was not taken into consideration, except that the voluntary individuals using the right ear photographs to avoid any damage to the ear integrity and aesthetic intervention. Sample photo taken from volunteer individuals is given in Figure-3.

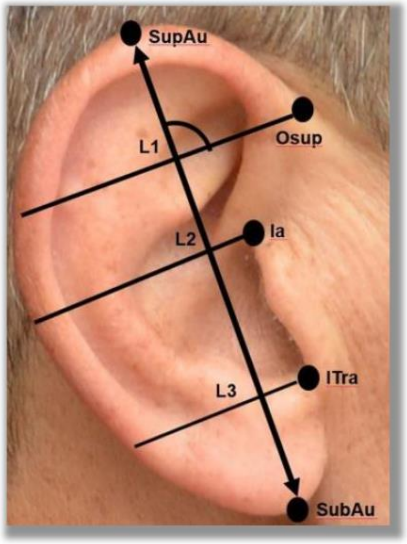


Figure 2 Sample Photo

Photographs of volunteers were taken with the Nikon D7000 professional camera used by the same person, at a distance of approximately five feet (1.54 meters) to provide the best depth. Avoid to reflecting light and due to the pictures can be easily extracted during the introduction of the programs, photograph setting to background is black, exposure time 1/60 sec, focal length 50 mm, 3.1 aperture, 24 bit deep, eight megapixel, 600 dpi resolution. Individuals are photographed in JPG format from the right. Photographs are taken by placing the camera on a water scale tripod (see Figure 4). All photos are taken from the same angle (lateral) and in the same position (Frankfurt plane) (see Figure 5).

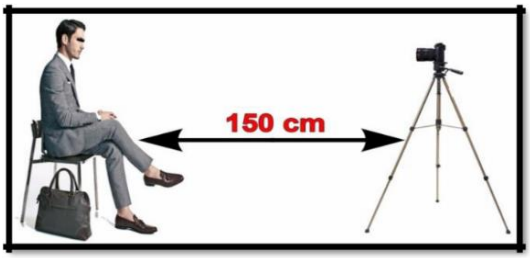


Figure 3 Photographing Position



Figure 4 Photographing Process

The human ear is the most prominent part of the facial area and is one of the characteristic parts of the head. In some studies, scientists have used the morphological features of the ears for individual identification. Ear length is calculated as a result of studies on various ear regions such as ear length on the tragus, ear length under the tragus, tragus length, ear width, concha length, concha width, lobule height, width of the outer ear lobule. Thanks to these results, the identity of individuals has been determined with high accuracy. Outer ear anatomy has been studied in many scientific studies and outer ear features have been evaluated with various parameters (Özkoçak & Gültekin, 2017).

In short, the facial area is very important in forensic studies (Özkoçak & Özdemir, 2017). Because one of the easiest ways to diagnose someone is to look at the individual's face. Although images obtained from CCTV cameras or the way of walking and the distance between the legs obtained from the photographic data has an important place in recent times, the face area will always be the first choice in recognizing people by friends and close family members. In terms of identification, the face area is vital for detecting criminals from an witness or video recording (Özkoçak & Gültekin, 2017).

Artificial Neural Networks

Artificial neural networks method is created by modeling the learning ability of the human brain mathematically using different algorithms. In the application of artificial neural networks to a problem, firstly; the relation between input and output parameters that create the problem is learned. The most important advantage of artificial neural networks mentioned in the literature is the problem is that they can work without the need for a mathematical model and produce logical and high accuracy outputs. In addition, even though some data are missing or inaccurate, or the relationship between the input variables of the problem is far from linearity that it does not prevent the network from producing acceptable outputs. Because of these advantages, artificial neural networks are frequently used in the solution of multi-dimensional and complex problems (Aydın et alç., 2018).

Modeling of artificial neural networks is based on the study and learning strategies of billions of nerve cells in the human brain. The central nerve system plays the most important role in the work of the brain. The brain processes and evaluates the information from the central nerve system stimuli by taking them continuously. The brain re-evaluates whether the response is effective by applying the decision taken after the evaluation process. Nerve system model is given in Figure 6.

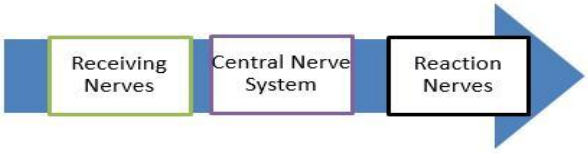


Figure 5 The functioning of the brain central nerve system

Neurons form the basis of the central nerve system. It is estimated that there are around 10 billion nerve cells in the human brain. In a biological nerve cell, there are three basic structures: the cell body, dendrites and axons. By connecting axons of one nerve cell to dendrites of another nerve cell, the synapse structure is formed. Communication between nerves takes place with these connections. The biological nerve cell is given in Figure 7.

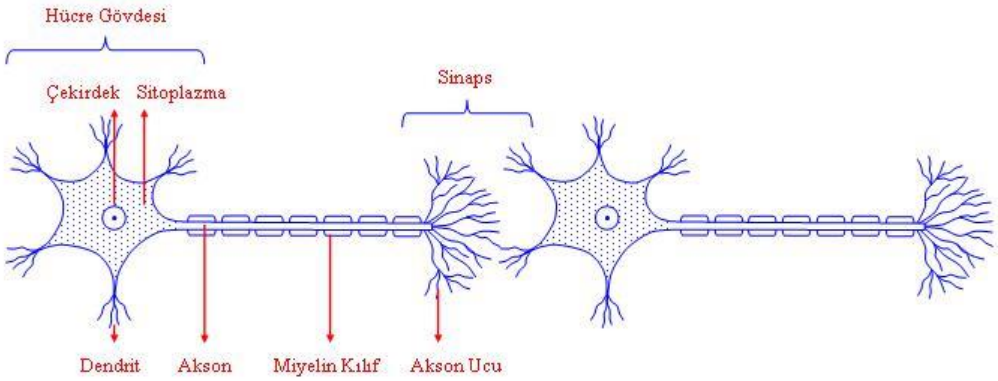


Figure 6 Modelling of the basic neuron

Artificial neural networks try to mimic the activities of biological nerve cells by mathematical methods. The mathematically designed artificial nerve model has four main parts. These parts;

I. The input or the inputs
II. The Weights
III. The activation function
IV. The output or the outputs

The inputs (xn) mean applied to the input of the network after the normalization process, weights mean elements that connect neurons and, elements with variable numerical values, the activation function means mathematical equality of the neuron structure, the output (yn) means the value of outputs to be generated in response to the data applied to the input of the network.

In multilayer sensor model, nerves are located parallel to the designed layers. Figure 8 shows the multi-layered sensor model.

While there are no neurons for computation in the first layer which the input layer, there are only inputs to feed the neurons in the first hidden layer. This layer is followed by the second hidden layer and other hidden layers. The last layer is the output layer. Generally, layers between the input

layer and the output layer are referred to as hidden layers. There is no connection between nodes in the same layer. Theoretically there are many hidden layers. But this significantly increases the complexity of the trained network. Accuracy, sturdiness and generalization in one or two hidden layer networks are provided in most cases (Öztemel, 2003; Sağıroğlu et al., 2003).

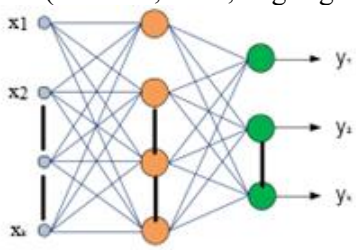


Figure 7 The multi-layered sensor model

The back propagation algorithm is used to grasp the pattern of the multilayer sensor and produce acceptable answers to the output of the problem. This algorithm reduces errors backwards from output to input. The block diagram of the back propagation algorithm is given in Figure 9.

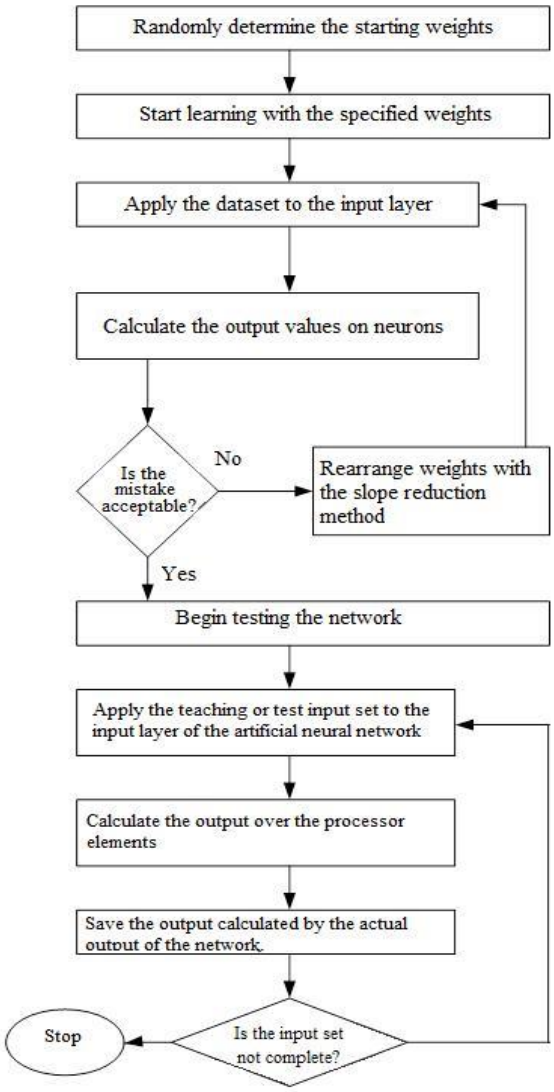


Figure 8 The back propagation algorithm

With this algorithm, the *wJı(t)* change in the weights between the *i* and *j* floor process elements is calculated. This statement is given in Equation (1).

η means learning coefficient, α means momentum coefficient and δj means a factor to be calculated for any J neuron in the intermediate or exit floor in Equation (1). For the output level, this factor is calculated as shown in Equation (2).

$$\delta j = \frac{\partial f}{\partial net_j}\left(y_j^{(t)} - y_j\right) \qquad (2)$$

The expression *netj* in Equation (2) is given in Equation (3).

$$net_j = \sum x_j w_{ji} \qquad (3)$$

$y_j^{(t)}$ specified in the Equation (2) is the target output of j processor element. For neurons in the intermediate floors, this factor is given in Equation (4).

$$\partial_i = \left(\frac{\partial f}{\partial net}\right)_j \left|\sum w_{qr}\right| \partial_q \qquad (4)$$

Since there is no target output for neurons in the intermediate floors, Equation (4) is used instead of Equation (2). Depending on this situation, starting from the exit floor, the *δj* factor is calculated for neurons in all floors. Depending on the formula in Equation (3), it is performed to updating weights for all connections. This is a gradual reduction algorithm and used to train multilayer sensor structures. Basically it is based on the principle of reducing the error between the desired output and the network output depending on the weights (Tekindal et al., 2016).

The selection of *β* and *α* values is important for a successful and rapid training process. The back propagation learning process is highly affected by these two coefficients. The selection of appropriate values for these coefficients is determined experimentally, but these values depend on applications and problems. Typical values for the learning coefficient range from 0.01 to 0.9. Smaller values are recommended for complex and difficult work (Öztemel, 2003; Sağıroğlu et al., 2003).

Artificial neural networks are systems that can learn events and flow diagrams using samples that are the products of real brain function that have been performed and tested by humans, and can determine how to produce responses against reactions from environmental stimuli. The information of the human brain is successfully applied in subjects such as learning, association, classification, generalization, feature determination and optimization, similar to the functional features that operate in a hierarchical order. Artificial neural networks can create their own experiences with the information they obtain from the examples presented to them from the problem space and can make very high decisions on similar topics. With these features artificial neural networks are capable of producing solutions to many anthropometric problems today (Özkoçak & Görgün, 2018).

Application of Artificial Neural Network to Problem

The fact that the data used in the training of the network in the applications of artificial neural networks includes all the parameters related to the problem space is one of the most important starting parameters for the solution of the problem. In order for artificial neural networks to learn the problem, the samples representing the problem must first be determined. In other words, it is not

possible to train the artificial neural network or to produce a solution to the problem, when there are not enough samples to train the designed network. If all parameters representing the overall problem cannot be shown to the network in all aspects, successful results cannot be obtained. For this reason, creating and obtaining examples to be used in the education of the network is of great importance (Sağıroğlu et al., 2003). The equation given in Equation 5 is used for the preparation of the data and normalization of the network to a range that can be processed mathematically.

$$n_v = \frac{\text{Real Value} - \text{Minimum Value}}{\text{Maximum Value} - \text{Minimum Value}} \quad (5)$$

Normalized datas are classified as training data, test data and verification data in The Matlab Program. Some of the data determined by the user is used to determine the values of the weights that are used in the training of the network and connect the artificial neural networks. During the training phase, each sample is shown to the network one by one, and the network is provided to grasp the patterns of the sample event through its own mechanisms. The training process is considered to be completed as soon as the network gives correct answers to all samples within acceptable limits. The test data consists of data used to check the problem learning status of the network. The network is put into use if it gives answers with acceptable accuracy to samples it has never seen before. If the performance of the network does not suit for the specified criteria, it is necessary to modify the network and train it with new data. With the verification data, the output values generated by the network are subjected to a final test, and the network topology with the least error is used, giving the best result (Özkoçak & Görgün, 2018).

In this study, the x and y coordinate points of the 11 anatomical points of the right ear of 450 volunteer individuals whose data are used which shown in one line and the data is transformed into a matrix consisting of 900 lines and 11 columns. 630 of 900 data are used for education, 180 for testing and 90 for verification. The data sharing rates of the network structure designed in The Matlab © program can be seen in Figure 10.

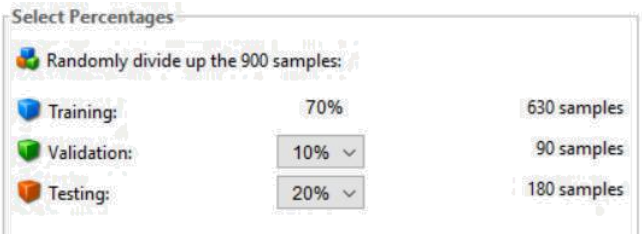


Figure 9 Data usage rates

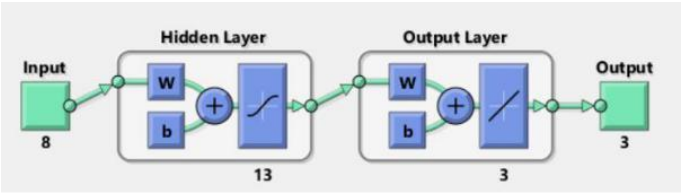


Figure 10 Network architectural structure

The training process of the network is completed at the end of 43 iterations and is given in Figure-12.

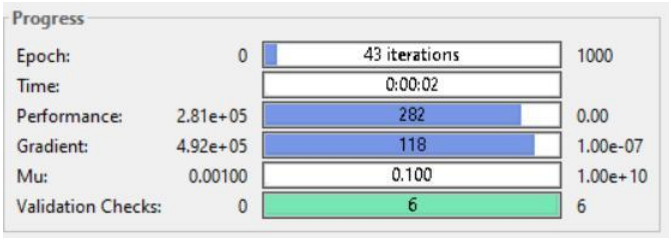


Figure 11 Training Progress

Data showing the performance analysis of the network is given in Figure 13. It is observed that the best validation performance is achieved at 37. Epoch.

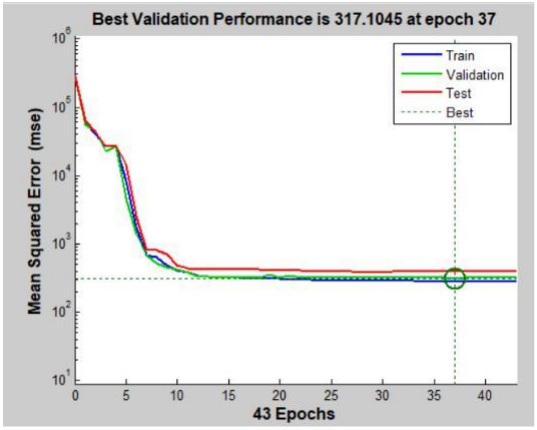


Figure 12 Performance analysis

Graphs showing the educational status of the network are given in Figure 14. "The gradient" term is the slope of the square of the error function between the actual value and the network's predicted value. Mu coefficient is the momentum coefficient that takes values in the literatüre from 0.8 to 1. The term of "Val fail" shows the error rates during the verification and approval phase.

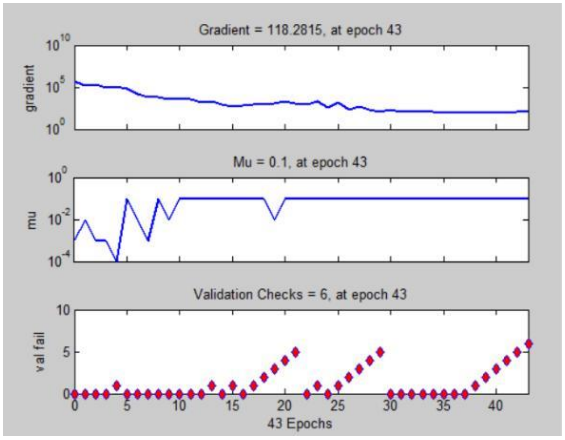


Figure 13 Educational status of the network

The histogram graph showing the errors between the actual output values and the output values produced by the network is given in Figure 15.

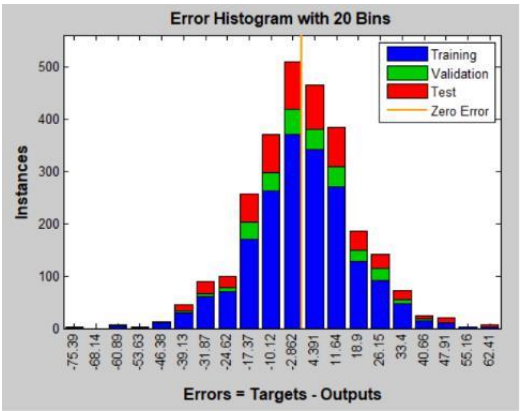


Figure 14 the Graph of Error Histogram

Regression analysis of the designed network is given in Figure 16. It is observed that the obtained data is real and the R coefficient is quite close to the value of 1 in the calculations made on the estimated outputs. This status indicates that the difference between the actual and predicted output values is rather small.

Data showing the general results produced by the network for the solution of the problem are presented in Figure 17. MSE (Minimum Square Error) is the sum of squares of the difference between the network's estimated output values and actual output values during the training, validation and testing stages. R value shows the correlation between the estimated output value of the network and the actual output value (Tekindal et al., 2014).

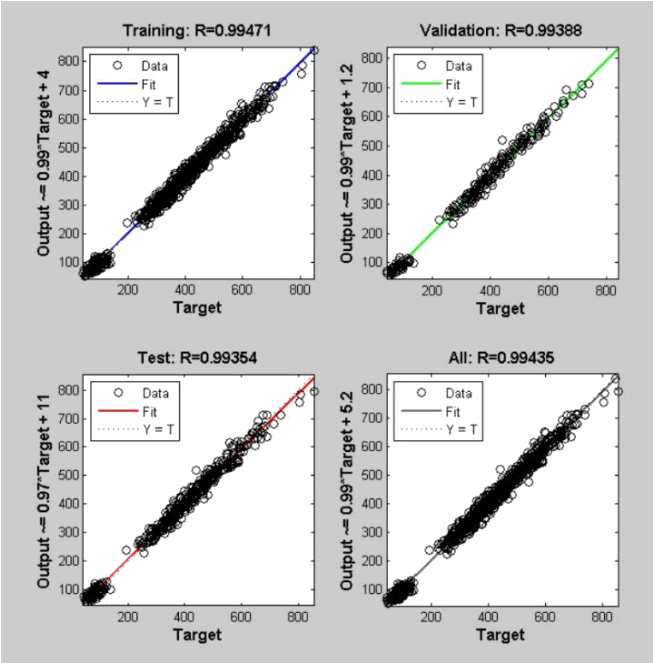


Figure 15 Regression Analysis

Results

	Samples	MSE	R
Training:	630	284.61622e-0	9.94709e-1
Validation:	90	317.10451e-0	9.93881e-1
Testing:	180	392.49041e-0	9.93544e-1

Figure 16 Results

The variable R can take values from -1 to 1. When the R value is squared, the difference between the estimated output and the actual output decreases. As a result of this decreases, closeness and correlation increases (Altın et al., 2018). When the square of the R value approximates -1, the difference between them increases and the similarity decreases. R^2correlation value between the outputs of the designed network and the actual values are calculated as approximately 0.94 in all datas. Therefore, the difference between the real value and the estimated value is found to be quite minor. In addition, the data obtained are compared with previous studies in the literature, consequently overlapping results are seen to be attained (Aslan & Cinemre, 2017; Özkoçak et al., 2017; Özkoçak & Alkaya, 2017; Özkoçak & Görgün, 2018).

Conclusion

Regression Curve Estimation Models are used in the first phase of the analysis. Estimation models of one or more curves can be obtained by regression analysis. The relationship between the variables can be distributed in linear or different ways. It is useful to use different models in these cases.

The answer to the question of whether the independent variable is sufficient to explain the dependent variable is expressed by the concept of determining the coefficient. The coefficient of determination is indicated by R^2 and it ranges from 0 to 1 ($0 \leq R^2 \leq$). As the R^2 value approaches 1, the independent variable is better at explaining the dependent variable.

It is necessary to choose the model with the highest coefficient of determination R^2 from the regression equations formed by the independent variables explaining the dependent variable (16).

The original data set is randomly divided into ten equal parts using the cross validation method 10 times in experimental studies. Then, one of these pieces is kept as validation data for testing the model, while the remaining nine pieces are used as training data. The cross validation process is carried out 10 times, each of the 10 pieces is provided to be used as validation data once.

Within the scope of this study, no feature selection method is applied to the attributes in the data set to obtain comparative results from decision tree algorithms; all attributes are taken into account in the formulation of the classification model. Data set does not contain any missing values. For this reason, the data set does not subjected to any pretreatment method.

These and similar studies will be the main subjects of Forensic Sciences, especially Forensic IT and Forensic Anthropology in the future. Considering that multidisciplinary studies are more advanced today, we estimate that artificial neural networks will be used more widely in Forensic Sciences and Forensic Anthropology fields, and that criminal events will illuminate easier, faster and more economically.

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