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Research Article

Classification of filigree silver with Artificial Neural Networks according to production methods

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ABSTRACT

The jewelry industry uses precious stones and metals in various ways while ornaments and jewelry are made. One of the methods used is the filigree method. The most critical factor in the filigree method is human and craftsmanship. However, rapid technological developments make the machine use in filigree mandatory. As a result, filigree products produced by handwork can be created using serial molds in the factory environment. This study aims to classify the molded product filigree silver using artificial neural networks. Filigree products produced by filigree masters and as mold products were compared to distinguish the filigree products. The color of the silver jewelry, the state of the jewelry, the silver setting status, the brass metal used in the silver jewelry, the form of the inner filling motif, the shape of the roof wire, the smoothness of the structure, the proper placement of the inner filling, the symmetrical status of the motifs on the jewelry are trained in the system using Deep Learning, which is an artificial neural networks method through thehe data collected from features such as the use of valuable or worthless stones. The success of classifying filigree jewelry handcrafts or mold products using Deep Learning through artificial neural network methods was evaluated. As a result of the study, the classification with deep learning was conducted successfully.

1. INTRODUCTION

Today, there is an understanding among the public that handmade products have higher quality than ready-made products produced by mass production methods in the factory. For instance, homemade food products are of better quality and tastier than factory-produced foods. At the same time, an entirely handmade car is more durable than cars produced in a factory environment with the help of robots on the mass production line. It can be said that handcrafted jewelry is more durable and of higher quality than mass-manufactured jewelry made out of the mold and that it is preferred among people compared to fabricated products. It is the process of melting filigree silver or gold into rod-shaped molds, obtaining the desired wire thickness by rolling these rods and making the wires into jewelry or ornaments by giving them shapes and patterns with various hand tools. This art is also called vav work or filigree among the public. Historically, the first filigree handcraft works were made in early 3000 BC in Mesopotamia and Egypt. The filigree jewelry processing method is commonly used, especially in Mardin and Midyat regions [1, 2]. The manufacture of filigree jewelry and ornaments, which is a process that requires workforce, is made entirely by hand labor, and requires a lengthy production process. It takes great effort and patience. Even the smallest piece of jewelry can take hours to build. With the development of technology, filigree-looking jewelry can be produced quickly, and a considerable number by using machine mold, and this fabricated product can be launched as if they were real filigree products.

This study aimed to evaluate the filigree products using the distinguishing features of hand-made and mold-made methods with the help of artificial neural networks. The deep learning method of artificial neural networks was used for this application. Many handcrafted and fabricated filigree products were examined, and the filigree masters, who lived in Midyat region and have been carrying out this work for many years, were required to assist in determining the distinguishing features between these two production methods. The resulting data was processed by using the Python programming language. In Figure 1 and Figure 2, pictures of handcrafted filigree and mold work products are shown. Artificial neural networks are computer systems. These systems help to realize the learning function, one of the basic features of the human brain, which has a complex structure. Learning performs its process with the help of networks created by the obtained data. These networks are like the nerve cells in the human brain. Each connection to these networks has a weight value, and the information is stored at these weights. Artificial neural networks develop a calculation method that differs from traditional calculation forms. These systems can achieve a successful result even when the data is insufficient. Artificial neural networks are one of the most powerful systems in which results are obtained, especially in classification, pattern recognition, filtering of signals, compression, and optimization of data [1-3].

Deep learning is a class of machine learning technique that utilizes many nonlinear hidden layers for supervised or unsupervised feature extraction, transformation, pattern analysis, and classification [3].

Figure 1. Handmade product filigree samples

Figure 2. Mold product filigree samples

Deep learning allows and enables calculation models consisting of multiple processing layers to learn data representation with numerous levels of abstraction. With these methods, speech recognition, visual object recognition, and object detection have vastly improved due to the state of technology in many other areas. Deep learning uses the backpropagation algorithm to show how a machine must change its internal parameters to calculate the representation at each layer from the presentation at the previous layer and explore the complex structure within complex datasets. Deep evolutionary networks are very effective at processing images, video, speech, and audio, while repetitive networks lead over sequential data such as text and address [4, 5].

In the design of artificial neural networks, perceptron structure was asked to be copied like the operational structure of human brain. The weights in the connections allow communication of the information processing elements. Each element has its memory. With all this, computer programs emulate biological neural networks. The Perceptron concept, which we can be called as the smallest module of this program, is essentially a single-layer processing unit [5].

The activation function processes the net input to the cell to determine the output that the cell will produce in response to that input. Since the derivative of the activation function is also used in feedback networks, attention is paid to selecting an easily calculated role to avoid slowing down the calculation. The structure of the artificial neural network is established based on a relational and differential realizable function. This function defines a linear neuron structure [4-6].

Fully connected layer is associated with all of the neurons in the previous layers in the fully connected layer diagram, each of the neurons in the respective layer. If a classification is to be made, the number of neurons in the last fully connected layer to be used must be the number of classes. Experience is related to the importance and effect of variables such as step size, dropout rate, batch size, and number of epochs (all train data is an epoch.) available by trial and error method [4-7].

2. APPLICATION AND METHOD

This study examined handcrafted jewelry produced by the filigree method and filigree-looking mold production jewelry. 100 filigree handmade and 100 filigree mold products were obtained from the market, and the distinguishing features between the two product groups were determined by examining them together with filigree Masters.

The distinguishing features identified are:

1. The color of the silver jewelry
2. Resource status in jewelry
3. Silver setting status
4. Brass used in silver jewelry
5. Internal filling form status
6. Roof wire form smoothness
7. Proper placement of inner filling
8. Symmetrical status of motifs on jewelry
9. Inner filling wire motif tightness condition
10. Use of precious or worthless stones

While filigree handcrafted silver is processed, blacked-out is also preferred in addition to the unique color of silver jewelry. Darkened charms both look beautiful in color and obtain an antique look. For this reason, in some cases, silver jewelry is blacked out by the Silver dimming (oxidation) method. This method is performed by dipping the lightly heated joint into liquid sulfur soap. In addition, with the rotating technique, also called rhodium-plated, some or all of the jewelry is coated with rhodium plum and colored. Although filigree products are produced from gold, it is also possible to come across gold-plated filigree products.

The welding process takes a significant place in handcrafted filigree products. Powder welding is used to boil the inner fillings into the roof. In other burning operations, Rod welding is used. The use of welding in fabricated products is almost non-existent. Only the products removed from the mold in pieces are boiled to be joined together. Also, to add visual value, any figure, shape, letter, or symbol produced from yellow brass material is burned or assembled into silver jewelry.

The silver has an international standard adjustment measure. The silver settings are defined within thousand systems, and the purest silver's value is considered 1000 settings. The silver used in the commercial field has a maximum purity setting of 999. Fabricated filigree products are generally 925carat. Ln the international market, 925-carat silver is also known as Sterling Silver. Handcrafted filigree products made in Mardin and Midyat regions are usually 950 carat.

In some cases, different metals may be boiled or assembled in addition to giving silver jewelry a more beautiful appearance. To add another image and beauty to silver jewelry, copper and zinc alloy brass metal is boiled or assembled in bright yellow color. Lt is mainly seen in filigree fabricated jewelry products.

In handcrafted filigree products, the thickness of the inner filling wire placed inside the roof is generally between 0.2 - 0.3 mm. Because the created inner fill is handcrafted, it may not be ideally placed. The thin wire appearance is obtained in fabricated mold products by designing the mold. A thicker internal filler wire thickness is designed. They can provide excellent processing because manufactured products are created in the mold.

Filigree products are manufactured jewelry. For this reason, there may be situations where the forms, such as smoothness and roundness in the roof parts, cannot be appropriately given. However, since machine mold is designed in filigree products, perfect forms, and shapes can be obtained.

Since human hands make handcrafted filigree products, defects may occur during the installation of the inner filler. In mold products, this possibility can only happen if there is a defect in the mold.

Since handcrafted filigrees are made with human hands, symmetrical defects may arise when the inner filling motifs are installed with roof wires. These errors are minimal in mold products.

Wire tightness distances of inner filling motifs in handcrafted filigree products are less. In fabricated products, the tightness rate is generally higher. Wires weave more frequently.

Precious or worthless stone use in fabricated filigree products is more significant than in handcrafted filigree products. This is because it can be designed to place as many stones as desired in the mold environment. This stone placement process in handmade filigree products is a complex task and requires patience and labor.

Two hundred filigree products and filigree-looking mold products obtained from the market with the help of these distinguishing features were examined in shape and taking into account the silver adjustment measure. The resulting data is shown in Table 1.

TABLE I
TABLE OF DATA ON THE DISTINGUISHING PROPERTIES OF FILIGREE AND MOLD WORK FILIGREE PRODUCTS

product	**silver jewelry color**	**welding condition in jewelry**	**Silver carat**	**use of brass material**	**smoothness of the inner filling motif**	**smoothness of the framework wire**	**inner filling placement**	**symmetrical status of motifs on jewelry**	**inner filling tightness ratio**	**precious stone**	**result**
	silver colour : 1	available: 1	925	available: 1	mold product regular:1	mold product regular:1	mold product regural:1	symmetrical : 1	little: 1	available: 1	
	blackout:2	unavailable:2	950	unavailable:2	mold product little defective:2	mold product little defective:2	mold product little defective:2	asymmetric: 2	very: 2	unavailable: 2	
	rhodium - plated:3	Additional piece welding available:3			handmade regular:3	handmade regular:3	handmade regular:3				
	gold-plated :4				handmade little defective:4	handmade little defective:4	handmade little defective:4				
	silver color and gold-plated : 5										
1	1	1	950	2	3	3	4	2	2	2	1
2	1	1	950	2	4	4	4	2	2	2	1
3	1	2	925	2	1	1	1	1	1	2	1
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.
198	1	1	950	2	4	4	3	2	2	2	1
199	1	1	925	2	3	3	3	1	2	2	0
200	2	2	925	2	1	1	1	1	2	1	0

In the light of these distinguishing features, the determined data of the compared jewels are listed with the help of Excel software, and the data set has been created. Results were observed with these used data. An educational model was created with the Keras and TensorFlow libraries, an open-source neural network using Python programming. Artificial neural networks are given to the system using the deep learning model.

The confusion matrix is a frequently used method to describe the generated performance of a classification model in which actual values are known on a set of test data. It is easy to understand, but its terminology is complicated. The confusion matrix we performed in this study is shown below:

```
Confusion Matrix
 [[13 0]
 [0 22]]
50/50 [=======================]- 0s 100us/step
Test set "accuracy" value 1.00
Test set "loss" value 0.00
```

In this study, 75% of the data set is separated for education while 25% is for the test. 200 samples were used for jewelry: 150 for training and the rest 50 for testing.

TABLE II
DATA SET TABLE OF FILIGREE PRODUCTS AND MOLD WORK FILIGREE PRODUCTS

Out[1]:

	0	1	2	3	4	5	6	7	8	9	10	11
0	1	1	1	950	2	3	3	4	2	2	2	1
1	2	1	1	950	2	4	4	4	2	2	2	1
2	3	1	2	925	2	1	1	1	1	1	2	0
3	4	2	3	925	1	2	1	2	1	1	1	0
4	5	2	3	925	2	1	2	1	1	1	1	0

TABLE III
DATA SET ENTRY TABLE OF FILIGREE PRODUCTS AND MOLD WORK FILIGREE PRODUCTS

Out[2]:

	0	1	2	3	4	5	6	7	8	9	10
0	1	1	1	950	2	3	3	4	2	2	2
1	2	1	1	950	2	4	4	4	2	2	2
2	3	1	2	925	2	1	1	1	1	1	2
3	4	2	3	925	1	2	1	2	1	1	1
4	5	2	3	925	2	1	2	1	1	1	1

3. RESULTS

In this study, handcrafted filigree products were found in the market, and mold filigree-looking products were provided; and then these products were examined, and a data set was obtained. An educational model was created by using Python Software with Keras and TensorFlow libraries, an open-source neural network. Artificial neural networks were given to the system using the deep learning model. In this developed system, the classification of filigree jewelry was successfully carried out. In the following figures (Figure 3 and 4), the classification success chart and the loss value chart that took place during training were shown. As can be seen from the figures, the success rate was achieved at a high rate of approximately 100%.

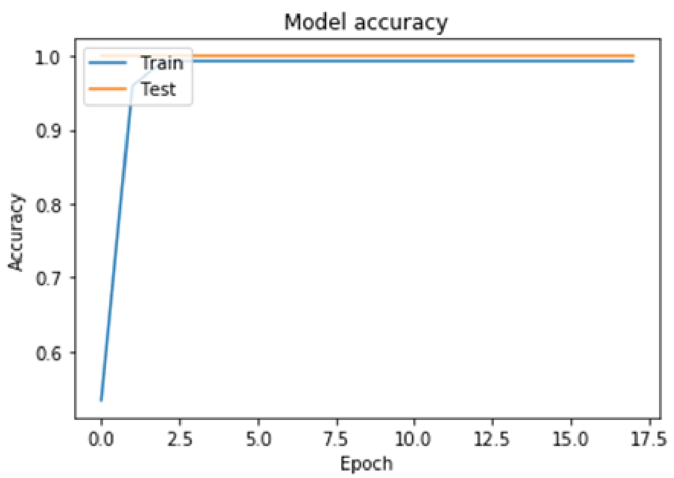

Figure 3. Classification success chart

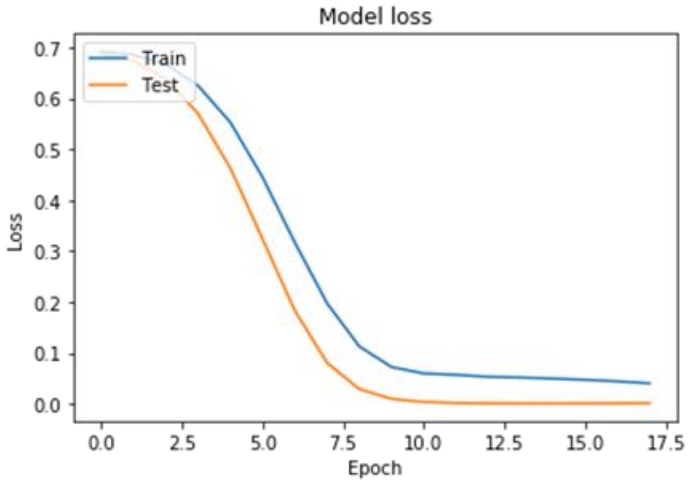

Figure 4. Loss value graph

As seen in Figure 3, with obtained data, the classification success of the computer is high.

In Figure 4, curves showing lost value data are given. The desired criterion in the lost value chart is that the angles decrease. As understood in the chart, the line of test and training data shows that success is in the desired results.

Creating a data set with more details made us achieve more realistic results. More distinguishing features can be added to improve the data set in this study. For more information, specific results can be obtained by adding data such as the determination of alloying rates of silver jewelry, the type of visual materials and precious stones used, the chemical structure of jewelry, and measurement values. Also, image processing can be carried out along with the application of deep learning in artificial neural networks. A data set can be created by processing many handcrafted filigree and mold work filigree images on the market. As a result, good results can be achieved.

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BIOGRAPHIES

Hamit ADİN born in 1972, received his PhD degree from the University of Fırat, Elazığ, Turkey in 2007 and has been Professor of Mechanical Engineering at the University of Batman, Turkey, since 2021. He has done research in the areas of mechanics, composite materials, adhesive, adhesion and finite element analysis. His research includes both theoretical and experimental studies.