Interpolation on data with multiple attributes by a neural network

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Abstract: High-dimensional data with two or more attributes are considered. A typical example of such data is face images of various individuals and expressions. In these cases, collecting a complete data set is often difficult since the number of combinations can be large.

In the present study, the authors propose a method to estimate a missing attribute data from other data. If this becomes possible, the pattern recognition of robust multiple attributes is expectable.

The key of this subject is appropriate extraction of the similarity that the face images of same individual or same expression have.

Begin, model [1] is a model that realizes the above key feature. However, experiments on application of bilinear model to classification of face images resulted in low performance [2].

Then, in this research, a nonlinear model on a neural network is adopted and usefulness of this model is experimentally confirmed.

1 Introduction

Real-world data often have two or more attributes. For example, face images have attributes “individual”, “expression”, and so on. By the method of recognizing each attribute independently, the relevance between data becomes low. It cannot utilize effectively the information which data have.

Then, a method of taking both attributes into consideration is desirable. We can expect more efficient face recognition with such a method. However, there are problems in this technique. It is obvious that the structure of this method is more complicated than the combination of classifiers for single attribute. Furthermore, data for all combinations of multiple attributes must be prepared, and therefore collection of data is difficult in reality from a physical factor. Then, in this research, we study interpolation of data for missing combinations of attributes.

2 The model of high-dimensional data with two attributes

In many cases, we can expect that high-dimensional data (e.g. face images) lie on a low-dimensional surface S (Fig. 1). Then, the data can be expressed by the shape of S and small number of parameters that specify a location on S.

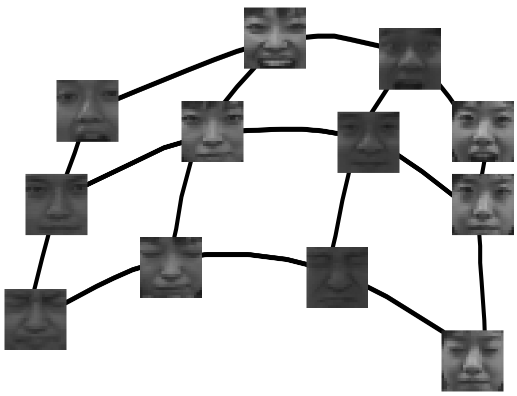

Figure 1: Low-dimensional surface S in high-dimensional data space

The following models are considered based on this view.

1) Express each attribute of given high-dimensional data $\boldsymbol{x}$ by a low-dimensional vector. (Expression part)

2) Reproduce the original data $\boldsymbol{x}$ from the vector expressions obtained in 1). (Reproduction part)

An attribute is mapped into a low-dimensional analog value vector at an expression part. Thereby, in the data of any combination, expressions become possible.

Parameters of the model are adjusted so that the existing data can be reproduced. And if this determined model is used, the data of the combination of the missing attribute can be presumed.

This structure has been proposed as the bilinear model by [1]. Since the form of a low dimensional surface S and specification of a location on S are both restricted, the bilinear model has an advantage that only small amount of calculations are required for parameter fitting. However, when the bilinear model was applied to recognition of the individual and expression of a face images, only low performance was obtained for classification. [2] Because distribution of face images in the image space is not necessarily linear.

3 Proposed methods

Then, in this research, the bilinear model is extended so that nonlinear relations can be expressed. In order to realize general nonlinear functions, a method based on a neural network is proposed. The neural network that is used in this research has four-layers. (Fig. 2)

1) Input layers

These are layers that receive the attributes of the data. Only the *i*th ingredient of an attribute value is 1, and other ingredients are expressed by value 0. For example, the data “3” is [0 0 1 0].

2) Expression layers

These are the layers that transform data from the input layers to low-dimensional vectors.

3) Hidden layer

Data is combined from the low dimension vector obtained in the expression layers.

4) Output layer

It is the layer connected to the output of this system. The output of this layer is reproduced data $\boldsymbol{x}$ which is an estimation of the original data $\boldsymbol{x}$.

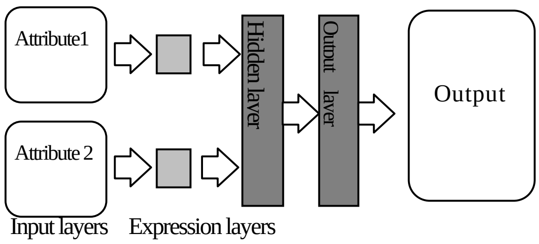

Figure 2: The four-layered neural network for the proposed method

In the above structure 1) and 2) correspond to the expression part in the previous section, while as 3) and 4) have undertaken the role of a reappearance part. For training of this network, data $\boldsymbol{x}$ with labels s,c of two attributes are presented.

By the way, when experimenting by the neural network, in one trial, weights cannot be adjusted in many cases to a desirable value. In other words, it sometimes converges on a partial solution or the wrong value plentifully. Then, several trials are performed and the average of the results data is taken. Thereby, the accuracy will improve.

4 Experiment on face image data

An experiment on face images was conducted. Twelve images of four persons and three expressions were prepared (Fig. 3). The size of each image is 72x72 pixels.

In this experiment, this face image data was compressed into ten dimensions using Principal Component Analysis. It experimented by making them into study data. In addition, for one of twelve data is used for presumption, it is not used for study. (Fig 4). Table 1 is a setup of the neural network that used in this experiment.

Fig. 5 shows the presumed result in one-shot trials, and Fig. 6 shows the average value of the presumed result in each trial. The error of the data used for study and Fig. 6 was taken. Moreover, the error of Fig. 4 and Fig. 6 was taken. Then, the error of Fig. 4 and Fig. 6 is the minimum, and in other words, this has succeeded in presumption.

Figure 3:The face image used for the experiment

Figure 4: The face data to presume

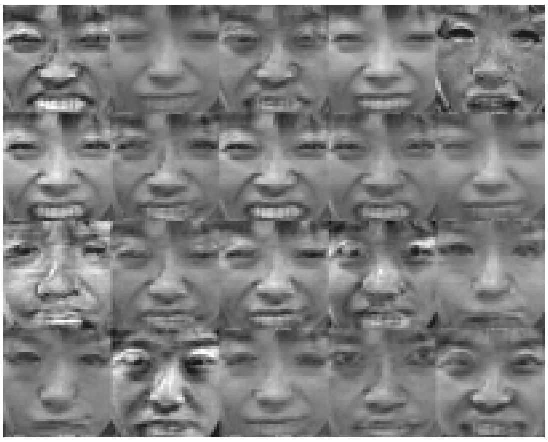

Figure 5: The presumed result for every trial

Figure 6: The presumed result in the average value of the data for every trial

Table 1: A setup of a neural network used in the simulation

The number of attributes	2	The number of neurons of an output layer	2
The kind of attribute 1	4	Study rate	0.1
The kind of attribute 2	3	Moment coefficient	0.9
The number of neurons of an expression layer	Each 2	The number of times of study	50000
The number of neurons of an hidden layer	20		

5 Conclusions

When data with two or more attributes was given, the technique of complementing data with the combination of the attribute that was missing from data with the combination of the given attribute was proposed. A neural network is used for the proposed method. It is a nonlinear extension of the existing bilinear model. It experimented using the face image. At this time, the good result was obtained by using the average value of a presumed value as data.

References

[1] Joshua B. Tenenbaum and William T. Freeman, “Separating Style and Content with Bilinear Models”, Neural Computation, 12, pp.1247-1283, 2000.

[2] Tetsuya KUROO, “Realization of the individual discernment and the expression recognition using bilinear model”, Graduation thesis of Information and Computer Science, Saitama University 2000,2001.