■ RESEARCH ARTICLE

Artificial Intelligence Based Decision Support System for Early Diagnosis of Mesothelioma Disease

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Abstract

Mesothelioma is a malignant tumor mostly seen in the membranes of heart and lungs. The exposure of these organs to substances such as asbestos and erionite causes mesothelioma disease. As a result of the deformation in these organs, shortness of breath, chest or back pain, cough and similar complaints occur. Because the symptoms of mesothelioma overlap with those of many other diseases, diagnosing the disease can be difficult and time-consuming. The goal of this study is to design an artificial intelligence-based early diagnosis system for mesothelioma disease. Two alternative neural network (NN) algorithms were utilized for this, and their results were analyzed. The performances of artificial neural network (ANN) and convolutional neural network (CNN) models were compared. F-measure rates for the designed ANN and CNN architectures were measured as 95% and 98%, respectively. The results showed that NN-based methods can be used in the early diagnosis of the disease. The software that will be built based on this model is expected to assist physicians in their decision-making processes.

Keywords: mesothelioma disease diagnosis, artificial intelligence, decision support system

1. Introduction

Every year, about 500 new people in Turkey are diagnosed with mesothelioma disease, which has a global incidence of 1-2 per 1 million people. The most common cause of the disease is the unconscious use of asbestos, which is known as white soil among the people [1-2]. The diagnosis of the disease is usually made after the patient consults a physician with symptoms such as shortness of breath, chest or back pain, and cough. However, since there are similar symptoms in some other lung diseases, none of the symptoms directly warns the physician about mesothelioma, and biopsy is often required for a definitive diagnosis. If the disease is detected in the first and second stages, it may be treated surgically, while in the third and fourth stages, chemotherapy and radiotherapy are used instead of surgery [3]. Early diagnosis, as in any cancer, is one of the most important factors that increase the chances of recovery in mesothelioma

There are various studies in the literature for automatic classification of mesothelioma disease. Blood test results and disease symptoms were used in these studies. Er et al. used probabilistic neural networks (PNN) and multilayer neural networks (MLNN) for classification of mesothelioma disease [4]. Şentürk and Çekiç used a series of machine learning methods such as Gradient Boosted Trees, K Nearest Neighborhood (k-NN), Random Forests (RF), Support Vector Machines (SVM) and Artificial Neural Networks

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(ANN) in their study on the same data set [5]. İlhan and Çelik used Decision Trees (DT), SVM and Multi-Layer Perceptron (MLP) in their study [6]. Win and Hamamoto used multiple machine learning methods for classification of the disease such as Linear Discriminant Analysis (LDA), Naive Bayes, Logistic regression (LogR), DT, RF, k-NN and SVM. [7]. In another study, Leong used genetic algorithms and ANN together as a hybrid model for classification [8].

In this study, a decision support system was designed to assist physicians in early diagnosis of mesothelioma. In this research, Convolutional Neural Networks (CNNs), which had never been used before in the classification of mesothelioma disease, were compared to ordinary Artificial Neural Network (ANN) algorithms. The findings show that both models can be successfully used in the classification of mesothelioma disease, and that CNN can be used as an alternative tool for performance improvement in similar data classification problems.

2. Materials Methods

2.1. Dataset Description

The data set used in this study was taken from the study published by ER et al in 2012 [4]. They shared their dataset in an international database [9]. 96 of the 324 samples in the data set have mesothelioma disease, while the remaining 228 do not. Table 1 shows the 34 input features for each sample in the data set.

Table 1. Features in the mesothelioma dataset

No	Features	No	Features	No	Features
1	Age	13	Weakness	25	Glucose
2	Gender	14	Habit of cigarette	26	Pleural lactic dehydrogenise
3	City	15	Performance status	27	Pleural protein
4	Asbestos exposure	16	White blood	28	Pleural albumin
5	Type of MM	17	Cell count (WBC)	29	Pleural glucose
6	Duration of asbestos exposure	18	Hemoglobin (HGB)	30	Dead or not
7	Diagnosis method	19	Platelet count (PLT)	31	Pleural effusion
8	Keep side	20	Sedimentation	32	Pleural thickness on tomography
9	Cytology	21	Blood lactic Dehydrogenise (LDH)	33	Pleural level of acidity (pH)
10	Duration of symptoms	22	Alkaline phosphatise (ALP)	34	C-reactive protein (CRP)
11	Dyspnoea	23	Total protein		
12	Ache on chest	24	Albumin		

2.2. Proposed Method

In this study, CNN and ordinary ANN methods were used for diagnosing mesothelioma disease. CNN is quite similar to ordinary ANNs whose connection between neurons is inspired by the visual cortex of animals. In comparison to ordinary ANNs, CNN's shared weight architecture causes a significant reduction in the number of network parameters, and at the same time, it prevents overfitting in problems with a high number of features and a low amount of data [10-11]. Thus, CNN has almost become the standard by preventing the problem of over-fitting in image classification problems where the number of input features is quite high. One of the reasons for CNN's limited use of traditional one-dimensional data processing problems is that its architecture requires it to accept input as two- or three-dimensional images. In standard data processing applications, ordinary ANNs with vector inputs tend to be the preferred model.

The designed ANN model in this study consists of a single hidden layer with 5 neurons. This model is a relatively shallow ANN with only 181 network parameters. Similarly, the designed CNN architecture is a very shallow CNN model consisting of a single convolution layer with six 2x2 filters and a total of 175 parameters. Figure 1 and Figure 2 show the designed ANN and CNN architectures, respectively.

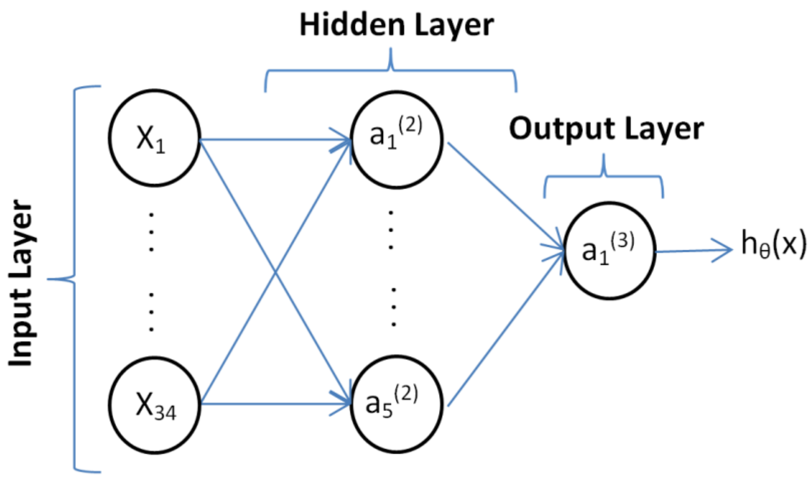

Figure 1. Designed ANN architecture

The feature space in vector form should be converted into a two-dimensional matrix form to fit the data set of 34 features to the CNN application. For this purpose, a feature column was added to the data set with the value zero for all samples, and the feature vector was transformed into a 5x7 feature matrix. The dataset was traditionally splitted into 2 separate clusters for 70% training and 30% testing. After splitting, the training and test set were normalized with the mean (μ) and standard deviation (σ) parameters obtained from the training set, as seen in equation 1. The hyper parameters used in CNN and ANN training are the same for both models and the stochastic gradient descent algorithm is used as the optimization algorithm with a learning rate of 0.01, the epoch number is 250 and the batch size is 32.

$$x = \frac{x - \mu}{\sigma} \qquad 1$$

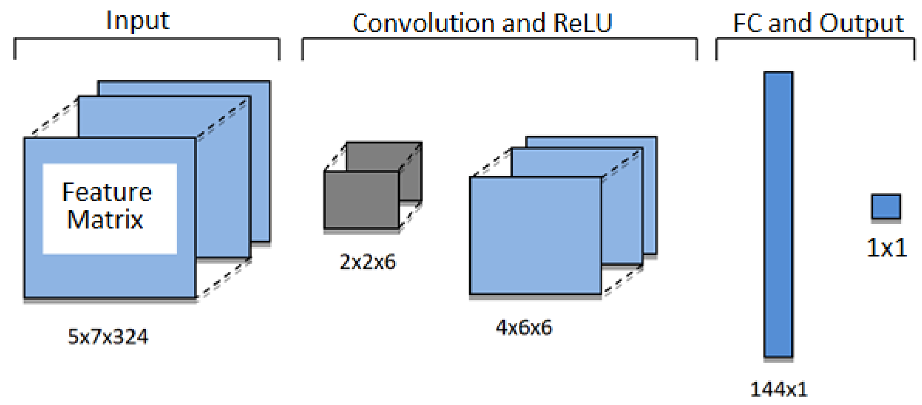

Figure 2. Designed CNN architecture.

3. Experimental Results

Figure 3 shows the confusion matrices obtained on the test sets belonging to both models. Metric values for both models shown in Table 2 were calculated on the test set using confusion matrices and equations 2-5. As seen in Table 2, the CNN model has reached higher evaluation metrics results than the ANN model on the classification of Mesothelioma disease.

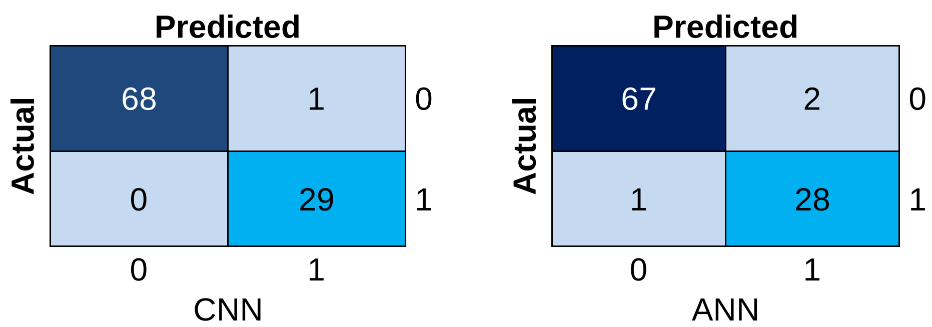

Figure 3. Confusion matrices for CNN and ANN models.

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN} \quad 2$$

$$Precision = \frac{TP}{TP + FP} \quad 3$$

$$Recall = \frac{TP}{TP + FN} \quad 4$$

$$F - Measure = \frac{2xPrecision * Recall}{Precision + Recall} \quad 5$$

Table 2. Metric results for CNN and ANN models.

	Accuracy	Precision	Recall	F-Measure
ANN	0,97	0,93	0,97	0,95
CNN	0,99	0,97	1	0,98

To provide a comparison, Figure 4 shows the loss and accuracy values obtained on the test and training sets during training on both models. Although the results obtained are quite close, the CNN model produces slightly better results than the ANN model. When the loss curves are examined, it is seen that the loss value decreases faster in both training and test set for the CNN model. In addition, in the accuracy curves, it is seen that the CNN model produces slightly better results on the test set. The results show that using CNN, as well as ordinary ANN, which is one of the most popular approaches used in one-dimensional data classification applications, can be an alternative solution for achieving higher success rates.

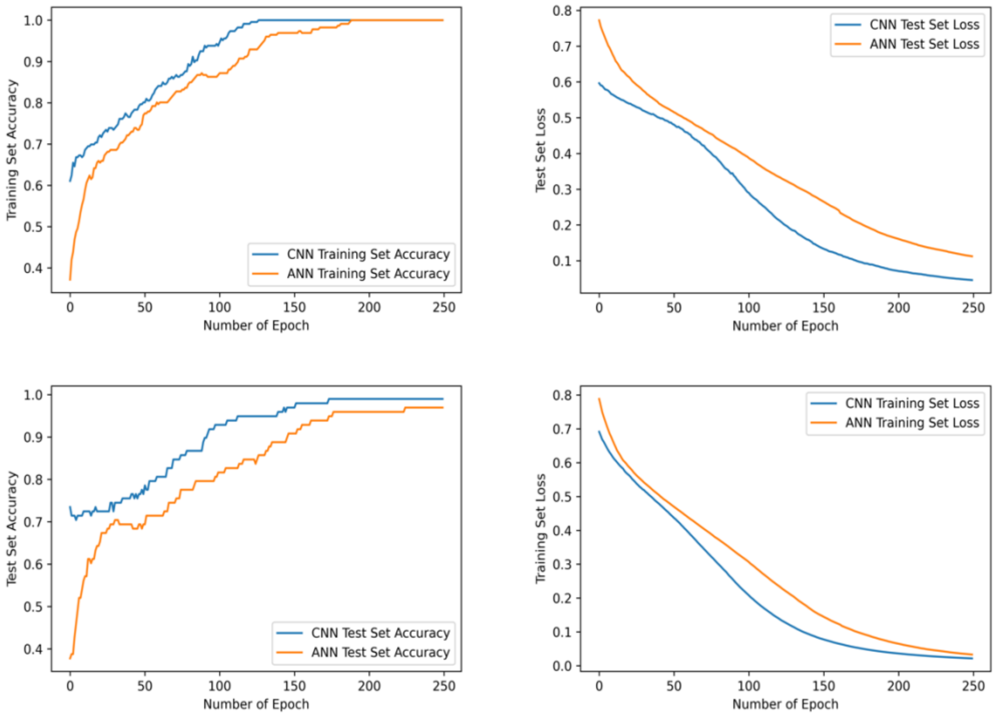

Figure 4. Learning Curves for CNN and ANN Models

4. Conclusion

In this study, classification of Mesothelioma disease was performed by CNN and ordinary ANN. The mesothelioma data set, which consists of 324 samples, has 34 input features and a class label. 70% of the data set was used for training models, while the remaining 30% was used for testing. Considering the results of the study, a high rate of accuracy has been achieved in classifying the disease with the recommended methods and it is thought that it can support the decision-making processes of physicians.

One factor reducing the success rate is the fact that the number of samples with the disease (96) in the dataset is substantially lower than the number of samples without the disease (228). By balancing the classes in the dataset, a higher accuracy can be achieved.

Furthermore, the successful implementation of CNN on a one-dimensional classical data set in the study, which is almost a standard method in image processing, shows that it can be applied on similar data sets.

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