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A data Mining Approach using CNN and LSTM to Predict Divorce before Marriage

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ABSTRACT

Divorce will have destructive spiritual and material effects, and unfortunately, in this regard recent statistics have shown that solutions provided for its prevention and reduction have not been effective. One of the effective solutions to reduce divorce in society is to review the background of the couple, which can provide valuable experiences to experts, and used by experts and family counselors. In this article, a method has been proposed that uses data mining and deep learning to help family counselors to predict the outcome of marriage as a practical tool. Reviewing the background of thousands of couples will provide a model for the coupe behavior analysis. The primary data of this study was collected from the information of 35,000 couples registered in the National Organization for Civil Registration of Iran during 2018-2019. In the current work, we proposed a method to predict divorce by combining a convolutional neural network (CNN) and long short-term memory (LSTM). In this hybrid method, key features in a dataset are selected using CNN layers, and then predicted using LSTM layers with an accuracy of 99.67 percent. A comparison of the method used in this article and Multilayer Perceptron (MLP) and CNN suggests that it has a higher degree of accuracy.

Keywords— ***Prediction, Divorce, Data Mining, LSTM, CNN.***

1. Introduction

The correct prediction of the future is always one of the main objectives of managers to make important decisions [1]. Therefore, for this purpose, the use of new prediction methods based on the principles of data mining and behavior analysis can be a solution. In recent years, data mining, prediction and decision-making based on the data collected in the past and analyzing and predicting the future have been considered, which provide great help solving various problems, and data mining has also been used in various sciences [2]. One of the important applications of data mining in psychology and family counseling, especially premarital counseling, is based on patterns extracted from other successful/unsuccessful marriages in the past years to predict the future [3]. Many family counselors are trying to guide families to have a successful life with many studies. One of the very important parameters used by family counselors in their consultations is to examine the situation of couples in different dimensions, which should match each other to have a successful life in the future. Counselors examine various parameters such as economic status, level of education, age, etc., and give the necessary advice about whether to marry. Therefore, the main challenge in this field is that psychological tests in this regard are mostly not localized, and since in different societies, cultural, social, religious issues, etc. are also very important parameters in the outcome of a couple's marriage, and only relying on psychological tests will not lead to correct prediction. Today, data mining as one of the most important and accurate methods can help couples and family counselors and psychologists to predict the success or failure of a marriage, and if data mining is done on local data of each region to extract different models of the success or failure of a marriage, along with psychological tests, can predict this. So far, this topic has not been discussed much in other studies, and even if there has been work in this field in different societies, the dataset was not real and related to Iran. In this study, it has been attempted to perform a combination of CNN and LSTM on the data extracted from the National Organization for Civil Registration of Iran during 2018-2019. In this study, by examining the characteristics of 35000 couples and the outcome of their marriage and presenting it by the proposed method, the outcome of new cases has been predicted, which has led to a high accuracy of prediction in the results. Also, the proposed method has been compared with MLP and CNN on the same dataset, which has obtained higher accuracy than these models. The method proposed in this study can be a web application and recommender system to family counselors and help to predict the success or failure of a couple's marriage along with psychological tests or even in the future, more accurate predictions can be obtained from increasing the data online and updating it through marriage and divorce offices. The present study is organized as follows. Section 2 provides literature review, Section 3 provides data collection, Section 4 provides the proposed method, Section 5 provides the evaluation of the results and finally Section 6 provides the conclusion.

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2. Literature Review

In the past years, various articles have been published on predicting the outcome of marriage using data mining.

Nasser -Ahzar University in an article predicted whether couples intend to divorce using deep learning. This method is a mathematical model that examines and learns the biological structure of living organisms. The accuracy of the method used after passing several validation cycles is 100% [4].

Ranjitha and Prabhu proposed a method by removing not useful features for the prediction of divorce with improved machinelearning techniques. They achieved an accuracy of 0.98. The proposed technique may use by family counseling professionals [5].

Kong and Chai in the article have addressed the prediction of divorce using correlation and artificial neural networks. In this article, the algorithms of multilayer neural networks and decision trees have been used [6].

Hafidz et al. proposed an ann method to predict divorce in Turkey. They achieved an accuracy of 0.98 and a Kappa value of 0.97. Their technique compared with the SVM model and two evaluation parameters the proposed method was better [7].

Sharma et al. proposed a method for prediction divorce with the perceptron learning models like random forests,decision tree, Naive Bayes,support vector machine, and K-nearest neighbor with the perceptron model, they achieved 98% accuracy [8].

Enggari and Defit proposed a method to divorce prediction with the apriori algorithm and the K-Means method. The number of divorce hearings is in the cluster Medium if the number of searches for PORN (porn), SEX, GAY, and LESBIAN is all in the cluster Medium [9].

Flores et al. proposed four deep learning models (perceptron, logistic regression,neural networks and randomized forest) and hybrid models. Every used model has 5 scenarios, and a total of 35 scenarios tests, they achieved accuracy,sensitivity and specificity are 0.98, 1.0, and 0.96. [10].

Sadiq Fareed et al. in a study proposed a method for predicting divorce using SVM and MLP, which is a collection of data by asking a series of questions by experts to determine whether a marriage will be successful in the future. The results of the evaluation predicted the model's accuracy to be 97% and finally the key indicators of divorce and the factors that are most important in predicting divorce were identified [11].

Narendran et al. analyzed a set of data collected on the premarital status of couples allowing premarital divorce prediction and determining whether a premarital marriage will be successful. Conclusion is based on the performance of multiple classification algorithms for divorce prediction datasets. Classification algorithms considered were random forest, decision tree, XGBoost classifier, bagging and voting [12].

None of the above studies have been conducted on the real dataset in Iran using the method proposed in this study. It seems that the proposed method can be used as a web application in the form of a decision support system by psychologists and family counselors with its high accuracy. So that it can help making decisions to predict the success or failure of a marriage and provide the necessary advice to couples.

3. Data Collection

The data used in this study has been prepared from the National Organization for Civil Registration of Iran with information on 33,000 marriages and divorces registered in Iran during 2018-2019. This dataset provides the information of couples, including level of education, economic status, number of marriages, number of divorces, the age of the spouses, etc. Of course, the data had flaws in some cases, and it was attempted to remove such flaws in case of disruption in the learning process, or replace them with appropriate values using statistical methods to prevent network instability. In fact, in this dataset, the information of people on the age, level of education, economic status, occupation, number of marriages, month of birth have been reviewed.

4. Proposed Method

Figure 1 shows the block diagram of the proposed method. In the following, various parts of the block diagram are explained. First, the data were pre-processed in terms of preparation for learning the system and the necessary changes were applied to the data. First, the qualitative data were converted into numerical data, for example, the economic status based on people's occupation was converted into numbers, or the level of education was converted into quantitative values according to Table 1 Also, people's economic status were stratified based on the type and level of job and other parameters. Finally, the data were normalized,

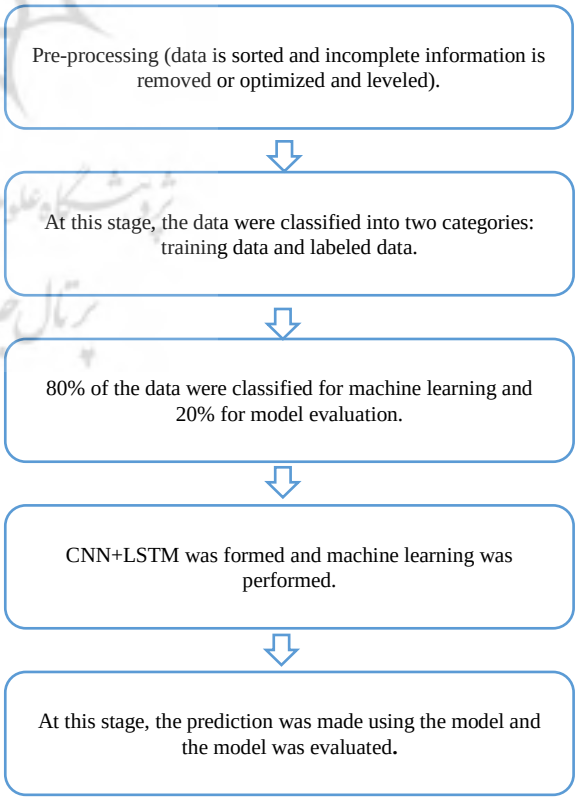

Figure. 1. The Block Diagram Of The Proposed Method

for example, fields without values, outlier data, noise, etc. were all corrected in the dataset so that the data can be evaluated by the system. Jupiter network, Python, Tensor Flow and Keras were used in this study.

Figure 2 shows the number of successful and unsuccessful marriages in the dataset. Column 0 represents the number of successful marriages and column 1 represents the number of unsuccessful marriages.

Figure 3 shows level of education of women. Figure 4 shows level of education of men. In the dataset, the horizontal axis represents different levels of education and the vertical axis represents the number of people in each level of education in the dataset.

Figures 5 and 6 show the age of women and men. As shown, the mean age of women in the dataset is 20 years.

Figure 7 shows the effect of literacy difference on the occurrence of divorce. As shown, green color shows successful marriages and red color shows unsuccessful marriages, which are arranged based on the level of

Table 1. Level of education

Diploma	***Associate degree***	***B.A***	***M.A***	***Ph.D.***
1	2	3	4	5

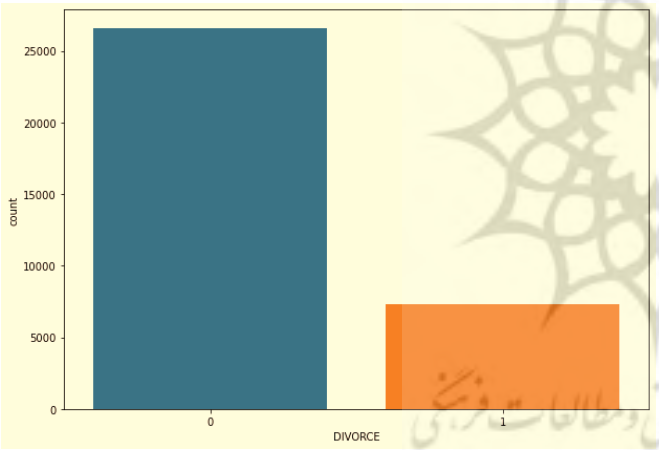

Figure. 2. Graphical report of the number of divorces in the database.

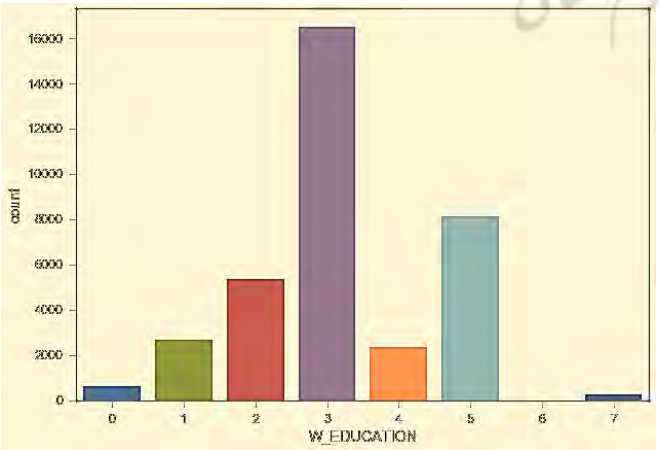

Figure. 3. Women's level of education .

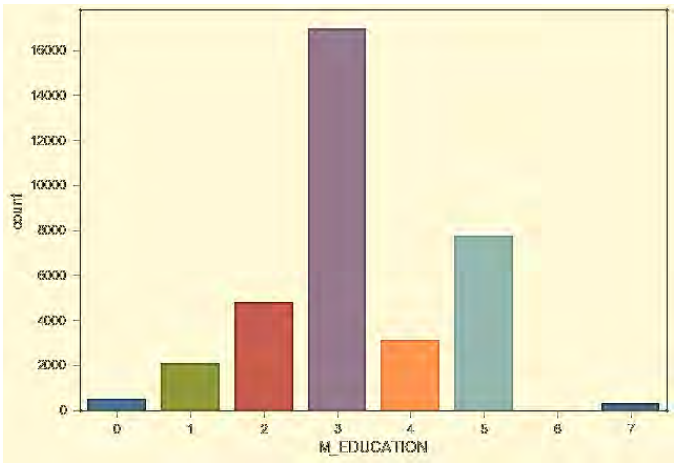

Figure. 4. Men's level of education.

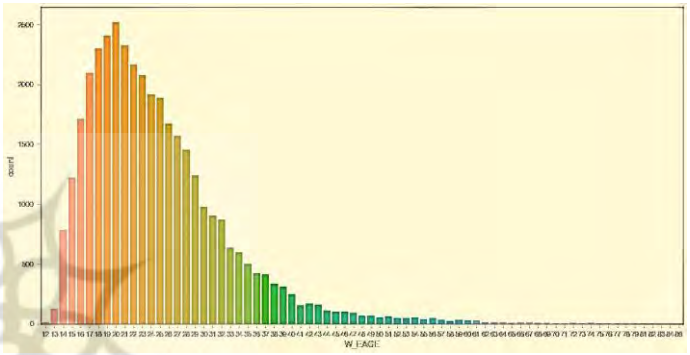

Figure. 5. Women's age.

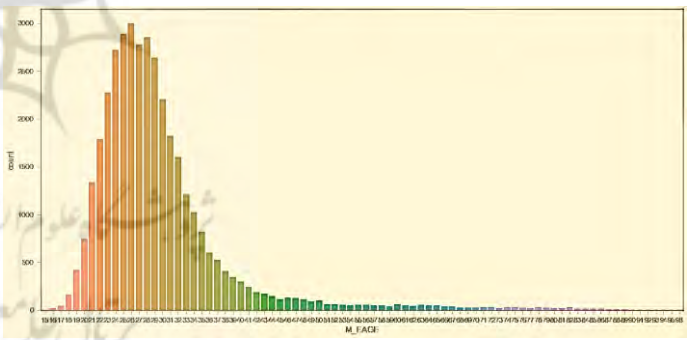

Figure. 6. Men's age.

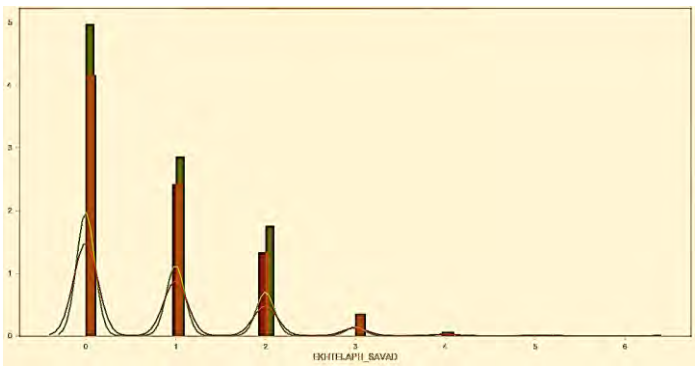

Figure. 7. Effect of level of education on divorce.

education. As shown, the most divorce is related to the elementary school.

Figure 8 shows the effect of age difference on divorce. As shown, red color indicates unsuccessful marriages and green color indicates successful marriages.

At this stage, the data is divided into two categories: training data (x) and labeled data (y). In fact, the x's are the input neurons of the neural network and the y's are the output of the network, and the proposed model is trained on these data. Tables 2 and 3 show the training and labeled data.

Next, the data is divided into training and test data. The test data will be used to test the model obtained from the training data. In the proposed method, the ratio of training data is 80% and test data is 20%. In section 1-4, the CNN+LSTM is explained.

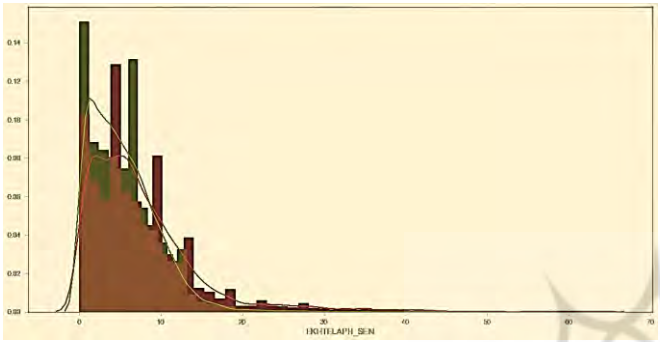

Figure. 8. Effect of age difference on divorce.

Table 2. Training data (x)

	radif	M_MONTH	M_EAGE	M_EDUCATION	M_M_TIME	W_MONTH	W_EAGE	W_EDUCATION	W_JOB	W_M_TIME	EKHTELAPH_SEN	EKHTELAPH_SAVAD
0	0	0.454545	0.185185	0.285714	0.166667	0.000000	0.090909	0.428571	0.4	0.000000	0.093750	0.166667
1	1	0.636364	0.172840	0.428571	0.500000	0.000000	0.181818	0.428571	0.4	0.000000	0.140625	0.000000
2	2	0.454545	0.246914	0.428571	0.500000	0.000000	0.909091	0.428571	0.4	0.000000	0.046875	0.000000
3	3	0.727273	0.283951	0.428571	0.500000	0.000000	0.909091	0.428571	0.4	0.000000	0.062500	0.000000
4	4	0.181818	0.172840	0.000000	0.000000	0.000000	0.363636	0.000000	0.0	0.000000	0.062500	0.000000
...	...	...	...	...	...	...	...	...	...	...	...	...
33873	37322	0.181818	0.271605	0.857143	0.833333	0.000000	0.454545	0.428571	0.4	0.032258	0.078125	0.500000
33874	37323	0.090909	0.358025	0.428571	0.500000	0.083333	0.000000	0.428571	0.4	0.032258	0.187500	0.000000
33875	37324	0.090909	0.407407	0.428571	0.500000	0.250000	0.545455	0.142857	0.0	0.032258	0.078125	0.333333
33876	37325	0.454545	0.283951	0.428571	0.500000	0.000000	0.000000	0.571429	0.4	0.032258	0.109375	0.166667
33877	37326	0.272727	0.074074	0.285714	0.166667	0.000000	0.454545	0.428571	0.4	0.000000	0.062500	0.166667

Table 3. Labeled data (y)

```
0        0
1        0
2        0
3        0
4        0
        ..
33873    1
33874    1
33875    1
33876    1
33877    1
Name: DIVORCE, Length: 33878, dtype: int64
```

4.1. CNN+LSTM

In the proposed method, 20 rounds of testing were investigated. Different layers are explained in this section.

Layer 1: Reshape Layer

According to the type of our data, which is the records in the dataset, we consider the first layer as the Reshape Layer.This layer has an input that contains 12 attributes in the dataset.

Layer 2: Conv1D Layer

The output of the previous layer is entered this layer. This layer is a one-dimensional convolution layer that performs multiplication or convolution of 32 filters in the previous layer. Finally, we will have 32 attribute maps with size 15 and 128 parameters.

Layer 3: Max Pooling1 D Layer

The output of the one-dimensional convolution layer is entered this layer to reduce the number of spatial dimensions, and after the integration operation, we will have 32 maps with size 6 (maximum integration function) and 0 parameter.

Layer 4: Conv1D Layer

The output of the previous layer is entered this layer. This layer is a one-dimensional convolution layer that performs multiplication or convolution of 64 filters in the previous layer. Finally, we will have 64 attribute maps with size 6 and 6208 parameters.

Layer 5: Max Pooling1 D Layer

The output of the one-dimensional convolution layer is entered this layer to reduce the number of spatial dimensions, and after the integration operation, we will have 64 maps with size 3 (maximum integration function) and 0 parameter.

Layer 6: Conv1D Layer

The output of the previous layer is entered into this layer. This layer is a one-dimensional convolution layer that performs multiplication or convolution of 256 filters in the previous layer. Finally, we will have 256 attribute maps with size 3 and the number of 49408 parameters.

Layer 7: Max Pooling1 D Layer

The output of the one-dimensional convolution layer is entered this layer to reduce the number of spatial dimensions, and after the integration operation, we will have 256 maps with size 1 (maximum integration function) and 0 parameter.

Layer 8: lstm Layer

The output of the previous layer is entered LSTM Layer to increase the power of prediction. This layer has 100 neurons or 100 hidden layers, and after its implementation, we will have 53200.

Layer 9: Flatten Layer

The output of the fourth layer is entered the smoothing layer to prepare for entering the classification layer, and the smoothing layer in the Keras Python library named Flatten, which has the best performance, reduces the number of parameters to 0.

Layer 10: fully connected layer

This layer, which is called dense in Python, is used to predict divorce in 2 classes: success and no success.

Table 4 shows the structure of the proposed method in Python.

Figure 9 shows the accuracy and error of the proposed method in Python.

Figure 10 shows the confusion matrix of the proposed method in Python.

Table 4. Structure of the proposed method of CNN+LSTM

Layer (type)	*Output Shape*	*Param#*
reshape_3 (Reshape)	(None, 12, 1)	0
conv1d_9 (Conv1D)	(None, 12, 32)	128
max_pooling1d_9 (MaxPooling1)	(None, 6, 32)	0
conv1d_10 (Conv1D)	(None, 6, 64)	6208
max_pooling1d_10	(None, 3, 64)	0
conv1d_11 (Conv1D)	(None, 3, 256)	49408
max_pooling1d_11	(None, 1, 256)	0
lstm_1 (LSTM)	(None, 100)	142800
flatten_3 (Flatten)	(None, 100)	0
dense_33 (Dense)	(None, 2)	202
Total params: 198,746 Trainable params: 198,746 Non-trainable params: 0		

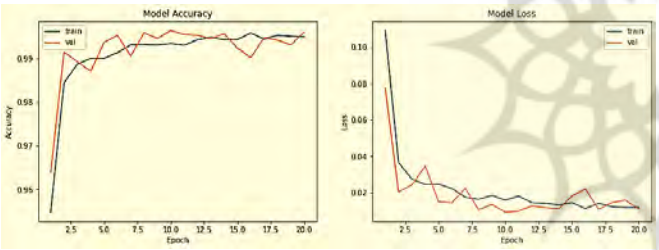

Figure. 9. Accuracy and error the proposed method of CNN+LSTM.

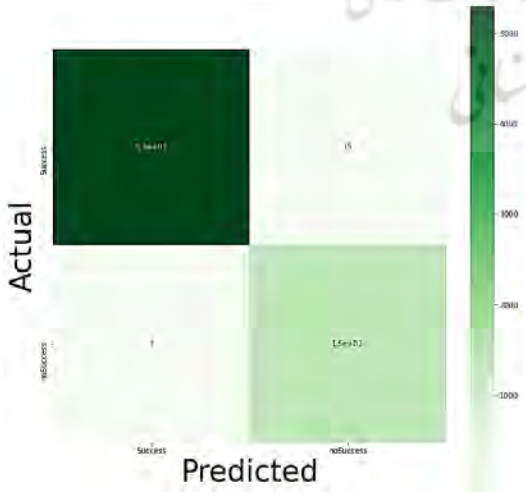

Figure. 10. Confusion matrix of the proposed method in Python.

5. Comparison of the Proposed Method with other Existing Methods

In this section, the proposed method of CNN+LSTM, CNN, and MLP are compared in Python.

5.1. MLP structure

In this study, the dataset is mentioned and 20 test rounds are run.

Layer 1: dense

As the first layer of MLP, the dense layer is used. This layer is fully connected and is used to connect neurons between different layers, which is considered a linear layer and its activation function is RELU. It has an input called input_dim, which has 12 selected attributes. This layer has 512 neurons, which finally creates 6500 parameters.

Layer 2: dropout

A single Dropout () layer is between the 2 layers dense and dropout for regularization. The output of the previous layer is entered this layer and finally 0 parameter is created.

Layer 3: dense

Another dense layer is used as the third layer of MLP, this layer is fully connected and is used to connect neurons between different layers, which is a linear layer and its activation function is RELU. It receives the output of the previous layer and has 500 neurons. Finally, 250,500 parameters are created.

Layer 4: dropout

The output of the previous layer is entered this layer for regularization. Finally, 0 parameter is created

Layer 5: dense

Another dense layer is used as the third layer of MLP. This layer is fully connected and used to connect neurons between different layers, which is a linear layer and its activation function is RELU. It receives the output of the previous layer and has 500 neurons. Finally, 250,500 parameters are created.

Layer 6: dropout

The output of the previous layer is entered this layer for regularization. Finally, 0 parameter is created.

Layer 7: dense

Another dense layer is used as the third layer of MLP. This layer is fully connected and used to connect neurons between different layers, which is a linear layer and its activation function is RELU. It receives the output of the previous layer and has 500 neurons. Finally, 250,500 parameters are created.

Layer 8: dropout

The output of the previous layer is entered into this layer for regularization. At the end of this layer, 0 parameters are created.

Layer 9: dense

Another dense layer is used as the third layer of MLP. This layer is fully connected and used to connect neurons between different layers, which is a linear layer and its activation function is RELU. It receives the output of the previous layer and has 500 neurons. Finally, 250,500 parameters are created.

Layer 10: dropout

The output of the previous layer is entered this layer for regularization. Finally, 0 parameter is created.

Layer 11: fully connected layer

This layer, which is called dense in Python, is used to predict divorce in 2 classes: success and no success.

Table 5 shows the structure of MLP.

Figure 11 shows the accuracy and error of MLP in Python. Figure 12 shows the confusion matrix of MLP in Python.

Table 5. Structure of MLP

Layer (type)	*Output Shape*	*Param#*
dense_34 (Dense)	(None, 500)	6500
dropout_25 (Dropout)	(None, 500)	0
dense_35 (Dense)	(None, 500)	250500
dropout_26 (Dropout)	(None, 500)	0
dense_36 (Dense)	(None, 500)	250500
dropout_27 (Dropout)	(None, 500)	0
dense_37 (Dense)	(None, 500)	250500
dropout_28 (Dropout)	(None, 500)	0
dense_38 (Dense)	(None, 500)	250500
dropout_29 (Dropout)	(None, 500)	0
dense_39 (Dense)	(None, 2)	1002
Total params: 1,009,502 Trainable params: 1,009,502 Non-trainable params: 0		

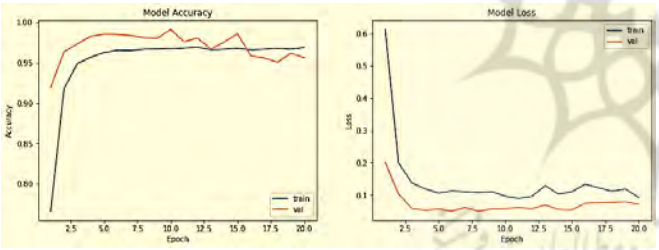

Figure. 11. Accuracy and error of MLP.

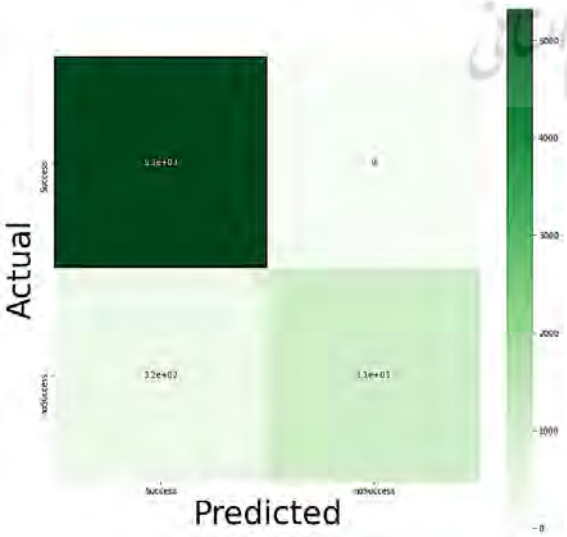

Figure. 12. MLP confusion matrix.

5.2. CNN structure

20 test rounds are run. Table 6 shows the structure of CNN in Python.

Layer 1: Reshape Layer

According to the type of our data, which is the records in the dataset, we consider the first layer as the Reshape Layer. This layer has an input that contains 12 attributes in the dataset.

Layer 2: Conv1D Layer

The output of the previous layer is entered this layer. This layer is a one-dimensional convolution layer that performs multiplication [6],or convolution of 32 filters in the previous layer. Finally, we will have 32 attribute maps with size 15 and 128 parameters.

Layer 3: Max Pooling1 D Layer

The output of the one-dimensional convolution layer is entered this layer to reduce the number of spatial dimensions, and after the integration operation, we will have 32 maps with size 6 (maximum integration function) and 0 parameter.

Layer 4: Conv1D Layer

The output of the previous layer is entered this layer. This layer is a one-dimensional convolution layer that performs multiplication or convolution of 64 filters in the previous layer. Finally, we will have 64 attribute maps with size 6 and 6208 parameters.

Layer 5: Max Pooling1 D Layer

The output of the one-dimensional convolution layer is entered this layer to reduce the number of spatial dimensions, and after the integration operation, we will have 64 maps with size 3 (maximum integration function) and 0 parameter.

Layer 6: Conv1D Layer

The output of the previous layer is entered this layer. This layer is a one-dimensional convolution layer that performs multiplication or convolution of 256 filters in the previous layer. At the end of this layer, we will have 256 feature maps with size 3 and the number of 49408 parameters.

Layer 7: Max Pooling1 D Layer

The output of the one-dimensional convolution layer is entered this layer to reduce the number of spatial dimensions, and after the integration operation, we will have 256 maps with size 1 (maximum integration function) and 0 parameters.

Layer 8: Flatten Layer

The output of the fourth layer is entered the smoothing layer to prepare for entering the classification layer, and the smoothing layer in the Keras Python library named Flatten, which has the best performance, reduces the number of parameters to 0.

Layer 9: fully connected layer

This layer, which is called dense in Python, is used to predict divorce in 2 classes: success and no success.

Figure 13 shows the accuracy and error of CNN in Python. Figure 14 shows the confusion matrix of CNN in Python.

Table 6. Structure of the convolutional neural network

Layer (type)	*Output Shape*	*Param#*
reshape_4 (Reshape)	(None, 12, 1)	0
conv1d_12 (Conv1D)	(None, 12, 32)	128
max_pooling1d_12	(None, 6, 32)	0
conv1d_13 (Conv1D)	(None, 6, 64)	6208
max_pooling1d_13	(None, 3, 64)	0
conv1d_14 (Conv1D)	(None, 3, 256)	49408
max_pooling1d_14	(None, 1, 256)	0
flatten_4 (Flatten)	(None, 256)	0
dense_40 (Dense)	(None, 2)	514
Total params: 56,258 Trainable params: 56,258 Non-trainable params: 0		

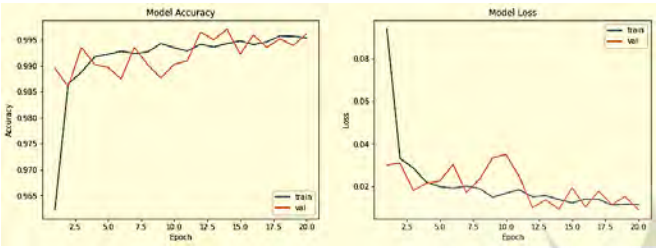

Figure. 13. Accuracy and error of CNN.

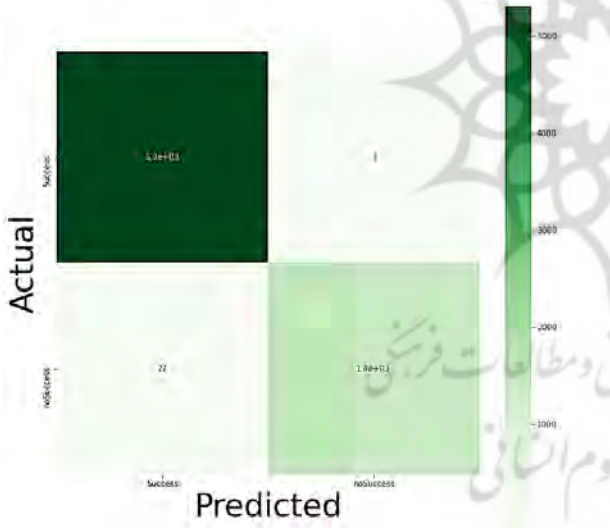

Figure. 14. CNN confusion matrix.

5.3. Results and validation

In this section, we made a prediction based on the experimental data and determined the accuracy of the model accordingly.

The present study was conducted aimed to classify marriages into successful/unsuccessful marriages. To evaluate classification, F1-score, recall, precision and accuracy were used.

Accuracy, Equ.(1), is a measure that is the result of dividing the number of correctly recognized cases by the total number of cases. Accuracy is the closeness of a calculated value to a natural or true value. In other words, this can measure the precise value whose accuracy can be measured.

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN} \quad (1)$$

Precision, Equ.(2), in deep learning architectures is calculated by dividing the number of properly labeled (labeled) things by the number of false-positive or true-positive ones.

$$precision = \frac{TP}{TP+FP} \quad (2)$$

Recall, Equ. (3), refers to the number of correctly classified items to the total number of classified in a class.

$$recall = \frac{TP}{TP+FN} \quad (3)$$

Based on recall and precision calculations, F1-score is calculated. F1-score is a useful measure to evaluate the classification efficiency and define the weighted mean recall and precision values.

The value of this criterion for the classification algorithm ideally is equal to 1 and in the worst case it is equal to zero [13].

As shown in Table 7, the proposed method has been compared with two other methods such as CNN and MLP. According to the results, the accuracy of the proposed method is higher compared to other methods, indicating the power of this method against other methods in predicting divorce before marriage based on specific models that are extracted from real data.

6. Conclusion and Future Studies

Since today, data analysis with different applications can help industries and sciences, so that valuable, accurate and reliable results can be obtained by predicting and extracting models and valuable data from past data. In this study, a combination of CNN and LSTM has been used to predict divorce before marriage. This method can help family counselors to provide a model for the couple behavior analysis by reviewing the background of thousands of couples and help family counselors predicting the outcome of marriage as a practical tool. In this way, since in life the cultural, social and value issues of different geographical regions are different from each other and the tests taken by psychologists cannot be accurate enough, if data mining can be used to propose a model localized in accordance with each country, province or geographical region, it was possible to retrieve and use similar models to predict the future, and design a system that can be used as a decision support system by family counselors and psychologists in pre-marriage tests to predict the success and / or failure of a marriage. In this study, the primary data set is related to the information of 35,000 couples registered in the National Organization for Civil Registration of Iran during 2018-2019, which predicted divorce before marriage by CNN and LSTM with accuracy of 99.67. Also, the method proposed in this article has been

Table 7. Comparison of the proposed method and CNN and MLP

Method	*Accuracy*	*Precision*	*Recall*	*F1-score*
CNN	0.995	0.997	0.981	0.989
MLP	0.952	1.0	0.779	0.876
CNN+LSTM	0.996	0.989	0.995	0.992

compared with MLP and CNN. In this study, the method is more accurate than other models, indicating the high power of the method proposed in this study compared to other methods.

The method proposed in this study is very effective and can help marriage counselors reaching the desired results regarding the prediction of the success and failure of marriage. It should be noted that better and more accurate results can be obtained from access to additional data regarding the couple's marriage, including the time the couple has lived together and other such information. In the future, if this model becomes a web application with the authority of family counselors as a decision support system alongside counselors can help improve their decision-making and counseling.

Declarations

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Authors' contributions

TT: Study design, acquisition of data, interpretation of the results, statistical analysis, drafting the manuscript; HS: Study design, interpretation of the results, drafting the manuscript, revision of the manuscript; SS: Supervision, drafting the manuscript.

Conflict of interest

The authors declare that there is no conflict of interest.

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