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Research Article

Post-Traumatic Stress Disorder (PTSD) Management: A Machine Learning Approach

Mustafa Dağtekin[1], Engin Seven[2], Ahmet Emre Balsever[3], Eda Nur Var[4], Leyla Türker Şener[5], Nilüfer Alçalar[6], Betül Ensari[7], Tolga Ensari[8*]

[1] Istanbul University-Cerrahpasa, Department of Computer Engineering, Istanbul, Turkey (ORCID: 0000-0002-0797-9392)
[2] Istanbul University-Cerrahpasa, Department of Computer Engineering, Istanbul, Turkey (ORCID: 0000-0002-7994-2679)
[3] Istanbul University-Cerrahpasa, Department of Computer Engineering, Istanbul, Turkey (ORCID: 0000-0002-3655-1571)
[4] Istanbul University-Cerrahpasa, Department of Computer Engineering, Istanbul, Turkey
[5] Istanbul University, Istanbul Faculty of Medicine, Istanbul, Turkey (ORCID: 0000-0002-7317-9086)
[6] Istanbul University, Istanbul Faculty of Medicine, Istanbul, Turkey (ORCID: 0000-0001-9122-5421)
[7] Istanbul University, Faculty of Letters, Comparative Literature, Istanbul, Turkey (ORCID: 0000-0003-0425-7252)
[8] Istanbul University-Cerrahpasa, Department of Computer Engineering, Istanbul, Turkey (ORCID: 0000-0003-0896-3058)

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Abstract

Post-traumatic stress disorder (PTSD) is defined as a traumatic injury developed after facing or witnessing a life-threatening experience or event such as a natural disaster, a pandemic, a serious accident, a terrorist act, war/combat, rape or other violent personal assault. Machine Learning (ML) has been widening its scope on psychological and physical healthcare for a decade by predicting detecting, personalizing, digitalizing, preventing risks, monitoring, and classifying PTSD based clinical mental diseases. In this study, we predict PTSD scores of the participants obtained from Mississippi-Civilian Version Scale and DSM-5 (PCL-5) Scale by applying ML. For our experiments we used the following methods namely k-nearest neighbor (k-nn), support vector machine (SVM), decision tree (DT), Gaussian Naive Bayes (GNB) and artificial neural networks (ANN). According to the comparison of the prediction results Considering PTSD prediction classification performance results for Mississippi (Civilian version) scale data set in comparison to the above mentioned methods, ANN offers the best prediction in terms of accuracy, F1 score and recall. However, Gaussian Naive Bayes (GNB) gives the best prediction score in terms of precision. On the other hand, when we applied all these methods to DSM-5 (PCL-5) scale data set, we have observed that ANN offers the best prediction in terms of accuracies, F1 score and precision. Nevertheless, in terms of recall Gaussian Naive Bayes (GNB) gives the best prediction score. By applying all the methods to these two different data sets and comparing the results, we demonstrate which method can be more efficient in prediction, diagnosis and monitoring the patients with PTSD.

Keywords: Post-traumatic stress disorder (PTSD), PTSD score prediction, Machine Learning, Artificial Neural Networks (ANN).

Travma Sonrası Stres Bozukluğu Yönetimi: Makine Öğrenmesi Yaklaşımı

Öz

Travma sonrası stres bozukluğu (TSSB), doğal afet, salgın, ciddi bir kaza, terör eylemi, kavga/savaş, tecavüz veya benzeri, yaşamı tehdit eden bir deneyim veya olay yaşayan veya buna tanık olan kişide meydana gelen travmatik bir yaralanma olarak tanımlanır. Makine öğrenmesi (MÖ), TSSB tabanlı klinik ruhsal hastalıkları tespit etme, dijitalleştirme, riskleri önleme, izleme, sınıflandırarak ve kişilere özgü sonuçlar çıkararak psikolojik ve fiziksel sağlık üzerinde son on yıldır çalışmalarını arttırarak devam ettirmektedir. Bu çalışmada, Mississippi-Civilian Versiyon Veri Seti ve DSM-5 (PCL-5) Veri Setini MÖ'nde kullanarak, katılımcıların TSSB skorlarını öngördük. Deneylerimiz için k-en yakın komşu (k-nn), Destek Vektör Makinesi (DVM), karar ağacı (KA), Gauss Naive Bayes (GNB)

[*] Corresponding Author: İstanbul Üniversitesi, Mühendislik Fakültesi, Bilgisayar Mühendisliği Bölümü, İstanbul, Türkiye, ORCID: 0000-0003-0896-3058, ensari@istanbul.edu.tr

ve Yapay Sinir Ağları (YSA) yöntemleri kullandık. Tahmin sonuçlarının karşılaştırılmasına göre Mississippi Ölçeği Veri Seti için TSSB tahmini sınıflandırma performans sonuçları göz önüne alındığında, YSA'nın doğruluk, F1 skoru ve anımsatma açısından en iyi tahmin sonuçlarını verdiğini gözlemledik. Hassasiyet alanında ise Gauss Naive Bayes (GNB) en iyi tahmin sonucunu verdi. Öte yandan, tüm bu yöntemleri DSM-5 (PCL-5) ölçekli veri setine uyguladığımızda YSA'nın doğruluk, F1 skoru ve hassasiyet açısından en iyi sonuçları verdiğini gözlemledik. Anımsatma açısından ise, Gaussian Naive Bayes (GNB) en iyi tahmin skorunu verdi. Tüm yöntemleri bu iki farklı veri setinde deneyip sonuçları karşılaştırarak, TSSB olan hastaların tahmin, tanı ve izlenmesinde hangi yöntemin daha verimli olabileceğini gösterdik.

Anahtar Kelimeler: Travma Sonrası Stres Bozukluğu (TSSB), TSSB skor tahmini, Makine Öğrenmesi, Yapay Sinir Ağları (YSA).

1. Introduction

Post traumatic stress disorder (PTSD) has become a centre of attention since the Second World War. According to recent studies many people suffer from PTSD as a result of life-threatening events they have been to exposed to. Most of the survivors of wars, natural disasters (Covid-19, epidemics, earthquakes, tornadoes, and tsunamis), fatal accidents, and attacks (rape, mass-shootings and September 9/11) develop PTSD (R. Levy et al., 2019; A. N. Karancı et al., 2009; J. L. Gradus et al., 2017; J. L. Steel et al., 2011; T. Roushan et al., 2019) and suffer from nightmares, flashbacks and disturbing thoughts (T. Armstrong et al., 2020). PTSD is a mental disorder that is not generally diagnosed and treated, which affects society at many levels.

What makes PTSD challenging is that it is inherently heterogeneous. Thus it stems from interaction between diverse psychological, social and biological factors. In order to gather this heterogeneous data, to process and draw meaningful conclusions from it, it is crucial to apply machine learning. For this, intelligent software based on machine learning can be produced. Thus, the data collected from different sources are processed together and automatic diagnosis is made, and these processes are made faster and automated with smart software (D. Banerjee et al., 2019; D. Borsboom et al., 2017; C. Heim et al., 2016; R. Levy et al., 2019).

Machine learning has been used in medical science for a long time. PTSD is one of the new areas where machine learning can be used and machine learning seems promising to provide the best and most rapid diagnosis, early predictions at risk group and monitoring. To understand the reasons that trigger PTSD, it is crucial to investigate the psychological, social, biological, genetic, immune and endocrine factors. A review of some studies underlines the rapidly evolving field of applied machine learning for PTSD research and demonstrates the importance of machine learning methods as successful tools for gaining important scientific insights into PTSD (D. Banerjee et al., 2019; D. Borsboom et al., 2017; C. Heim et al., 2016; R. Levy et al., 2019; A. N. Karancı et al., 2009; I. R. Galatzer et al., 2014; J. L. Gradus et al., 2017; J. L. Steel et al., 2011; A. G. Ünlü et al., 2014; F. Lamos et al., 2020; T. Wörtwein et al., 2017; S. İ. Omurca et al., 2015). In this area, logistic regression and principal component analysis (PCA) are statistical methods and several supervised and unsupervised machine learning methods also have been used in this field. Multiple sources of information have been used in PTSD analysis. The goal of the studies is to gain more scientific insights into PTSD by utilizing latent growth mixture modelling (LGMM), known as one of the unsupervised machine learning methods. It also offers to use some techniques of supervised machine learning methods such as logistic regression, support vector machines (SVM), random forests, neural networks, deep belief networks (DBN), restricted boltzmann machine (RBM) and transfer learning (D. Banerjee et al., 2097; D. Borsboom et al., 2017; C. Heim et al., 2016; R. Levy et al., 2019; A. N. Karancı et al., 2009; A. G. Ünlü et al., 2014; A.Priyaa et al., 2020). In (R. Levy et al., 2019), authors have used Markov Boundary Induction algorithm for feature selection process and random forest, AdaBoost, Kernel ridge regression and Bayesian binary regression as classification algorithms. In (T. Wörtwein et al., 2017), the behaviors and facial expressions of self-reported patients of PTSD are examined during an automated PTSD screening interview in order to elicit the most indicative multimodal behaviors for PTSD. In the aim of helping clinician and mental healthcare providers who have limited time to evaluate the questionnaires, the researchers utilize an information gain driven ranking procedure to identify the most informative questions. Similarly, researchers in (T. Roushan et al., 2019) developed a predictive model that can identify the gestures resulting in the prediction of risky behaviors among the veterans who suffer from PTSD.

With this study, we aim to enable mental healthcare providers to predict people with PTSD easily, monitor of people diagnosed with PTSD more often by using machine learning-based decision support software. Our study might be useful for further studies and developments in the sense of building a system that diagnoses the patient with PTSD by integrating with different types of data such as speech, handwriting and blood test etc. This smart system can monitor patients with PTSD online and report the decision-based results to health care providers periodically. Thus, machine learning techniques provide a better approach to PTSD patients due to their etiological and clinical heterogeneity in clinical practice for the benefit of patients at an individual level (F. Lamos et al., 2020)..

2. Machine Learning Methods and Experimental Studies

We used k-nearest neighbor (k-nn), support vector machine (SVM), decision tree (DT), Gaussian Naive Bayes (GNB) and artificial neural networks (ANN) machine learning methods in order to predict the PTSD score. We used synthetic data sets for both Mississippi (Civilian Version) scale and DSM-5 (PCL-5) scale.

The k-nearest neighbor (k-nn) method is an instance-based learning method that is widely used classifier. k-nn is a type of non-parametric method. This technique has been used in many applications in areas, it is simple and efficient also can be used for classification or regression. Neighbors used in the meaning that there is a measure of distance or dissimilarity between samples based on independent instances. The remarkable fact is that if our training set has a large number of samples, this simple and intuitive approach of using the nearest neighbor to classify cases can be very powerful.

The support vector machine (SVM) algorithm is a very popular technique that can be used in both classification and regression. The main principle of SVM is that try to find the line that separates the two or more classes as a boundary. The important point is the boundary line should create maximum separation between the classes. The SVM is based on a statistical learning framework. SVM uses marked training examples according to categories to build a model that assigns new samples to one group or the other. In addition to performing on linear models, SVMs can also be used for non-linear classification efficiently.

A decision tree (DT) uses a tree-like model to support a decision process. This structure's algorithm has a unique way of creating conditional control statements. Decision trees are built by examining a set of training data in which the labels are known. Then they are used to classify previously unseen examples. If training can be done on high-quality data, decision trees can make very accurate results.

Gaussian Naive Bayes (GNB) classifiers belong to a family of simple probabilistic classifiers. This is an extended and easiest to work version of Naive Bayes by using Gaussian distribution. It is enough to calculate the standard deviation and the mean from your data. Technique based on Bayes Theorem with the opinion of independence among the predictors.

Artificial Neural Networks (ANN) can be described as a structure of processing that are simply modeled according to the neural structure of a brain. The difference between the two is that the ANN might have hundreds or thousands of neurons, whereas the neural structure of an animal or human brain has billions. Neural nets are still a major research area since the 1970s. Neural nets are widely used for doing machine learning studies.

2.1. Data Sets and Scales:

We use Mississippi (Civilian Version) scale and DSM-5 (PCL-5) scale in our experimental analysis to predict PTSD score by applying k-nn, SVM, DT, GNB and ANN methods. In the data preprocessing phase, we construct synthetic data set for both Mississippi (Civilian Version) scale and DSM-5 (PCL-5) scale. We produce 10.000 samples in order to train and test our system. 5-fold cross validation metric has been used for the performance test.

2.1.1. Mississippi (Civilian Version) data set and scale:

Mississippi (Civilian Version) scale has been presented by U.S. Department of Veterans Affairs and National Centre of PTSD (F. H. Norris et al., 1996). It consists of 35-item self report measure for civil populations. These items' main features are abuse, suicidality and depression. Each item has 5 replies as points from 1 to 5 like 'not all true, slightly true, somewhat true, very true, extremely true'. Diagnosis cutoff score has been set 135. There are 10.000 samples in this data set.

2.1.2. DSM-5 (PCL-5) data set and scale:

DSM-5 (PCL-5) scale is also one of the benchmark scale in the literature and we used it as a second scale (from U.S. National Centre of PTSD) and data set in our study (F. W. Weathers et al., 2013). It is 20 item-self report measures for PTSD diagnosis. With this scale doctors can monitor symptom change and make a PTSD diagnosis. Similar each item has 5 choices as 'not at all, a little bit, moderately, quite a bit and extremely'. Cutoff score has been set 31 points for diagnosis. There are also 10.000 samples in this data set.

2.2. Machine Learning Analysis:

K-nn, SVM, DT, GNB and ANN methods have been used for the PTSD prediction analyzes. We measure the performance of these methods with accuracy, F1 score, **precision** and recall metrics for Mississippi scale data set. The exact and comparative prediction results can be seen from Table I. ANN gives the best accuracy, F1 score and recall metrics. SVM and ANN gives the best performance results for precision metric result. Fig. 1 also illustrates the comparative prediction results in a graph.

Table 1. PTSD prediction classification performance results for Mississippi (Civilian Version) scale and data set

METHODS	ACCURACY (%)	F1 SCORE	PRECISION	RECALL
k-Nearest Neighbor (k-NN)	0.89	0.44	0.62	0.34
Support Vector Machines (SVM)	0.97	0.88	0.96	0.82
Decision Tree (DT)	0.82	0.31	0.30	0.32
Gaussian Naive Bayes (GNB)	0.92	0.49	1.0	0.33
Artificial Neural Networks (ANN)	0.98	0.92	0.96	0.89

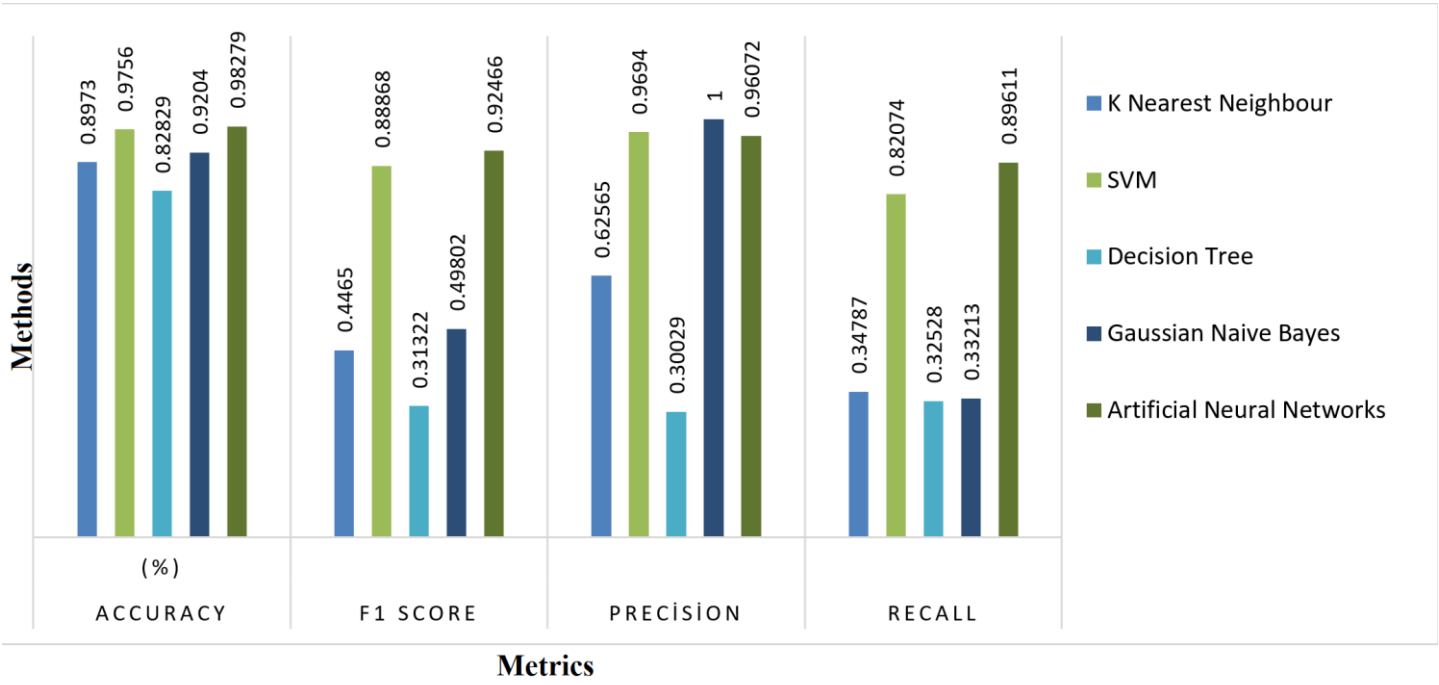

Fig. 1. PTSD prediction classification performance graphic for Mississippi (Civilian Version) scale and data set

The classification performance of PTSD for DSM-5 (PCL-5) scale data set can be seen from Table II. Also, illustrated version of Table II can be seen from Fig. 2. For this data set ANN is the best method in terms of accuracy, F1 score and precision metrics. Gaussian Naive Bayes is the best method in terms of recall metric.

Table 1I. PTSD prediction classification performance results for DSM-5 (PCL-5) scale and data set

METHODS	ACCURACY (%)	F1 SCORE	PRECISION	RECALL
k-Nearest Neighbor (k-NN)	0.82	0.83	0.82	0.84
Support Vector Machines (SVM)	0.97	0.97	0.97	0.97
Decision Tree (DT)	0.70	0.72	0.73	0.72
Gaussian Naive Bayes (GNB)	0.96	0.97	0.94	0.99
Artificial Neural Networks (ANN)	0.98	0.99	0.99	0.98

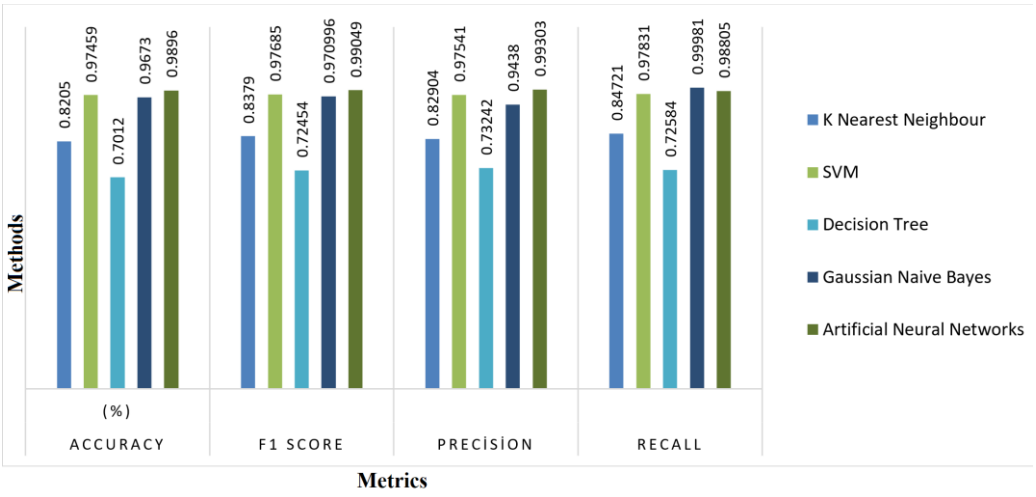

Fig. 2. PTSD prediction classification performance graphic for DSM-5 (PCL-5) scale and data set

3. Conclusion

In order to predict people with PTSD and monitor the patients with PTSD who suffer from nightmares, flashbacks, sadness, fear and disturbing thoughts with smart automatic detection analysis and at the same time to make patients and mental healthcare providers save time, we conducted this study. In this study, we utilized ML to predict PTSD scores of the participants who filled the questionnaire provided by Mississippi-Civilian Version Scale and DSM-5 (PCL-5) Scale. After applying k-nearest neighbor (k-nn), support vector machine (SVM), decision tree (DT), Gaussian Naive Bayes (GNB) and artificial neural networks (ANN) to our data set respectively, we compared the results in order to find out which application provides the best prediction results in terms of accuracy, F1 score, precision and recall metrics. According to the experimental results, in the case of Mississippi Civilian scale and data set that ANN gives the best accuracy, F1 score and recall whereas GNB gives the best performance for precision. On the other hand, in the case of DSM-5 (PCL-5) scale and data set, we detected that ANN offers the best prediction in terms of accuracy, F1 score and precision. However, in terms of recall Gaussian Naive Bayes (GNB) gives the best prediction score. The comparison of all the methods using two different data sets gives some insights into which method can be more efficient in PTSD prediction, diagnosis and monitoring the patients with PTSD. The observations we highlighted may inspire more ideas and encourage further analysis in this field.

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