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RESEARCH ARTICLE

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Detecting terror threat elements using natural language processing

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Abstract

In today's world, making millions of data understandable has become important. To take faster steps in criminal matters, especially by using these data, data analysis should be done quickly. In this context, sentiment analysis performed with the natural language processing (NLP) method of artificial intelligence enables the elimination of possible loss of life and property. In addition, by listening to all radio frequencies at the same time in possible terror areas, the attacks of terror organizations can be analyzed with natural language processing methods, so that the attack can be prevented before it takes place. In this study, natural language processing methods of artificial intelligence were used in the analysis of text, audio, and image data in the virtual environment for the detection of terror threat elements. In this way, it is aimed to ensure the healthy intervention of law enforcement officers and the security of life by analyzing the talks of terror elements in terror zones. For this purpose, an 85% accuracy rate was reached with the word/sentence vector creation method GloVe in the first model created with the Spark NLP library on textual data. In addition, a 74% accuracy rate was achieved with the LSTM method on audio data, while a 71% accuracy rate was achieved with the GRU method on visual data.

Keywords: Deep learning; natural language processing; data preprocessing; feature extraction; classification methods; terror-threat elements

1. Introduction

Artificial intelligence has taken place in many areas of daily life. Artificial intelligence, voice processing (voice recognition, voice assistant, voice response, speech-to-text synthesis, text-to-speech synthesis), text processing (translation services, online chat and assistant, social media analytics and sentiment analysis, personalized text editing and suggestion), image processing (security, face recognition and surveillance, finding photos in social media), analysis of health data and treatment planning (applications that assist healthcare personnel in the diagnosis and treatment planning process), autonomous driving systems (decision support systems in autonomous vehicles), big data analytics (behavior analysis with big data analysis), data processing (recommendation systems, ad suggestions, music suggestions, customer experience and smart campaign suggestions for the customer), smart applications in agriculture and livestock (image processing-based precision agriculture applications, precision animal production), cyber It has increased its use day by day in areas such as security (expert system for cyber-attack detection and prevention, malware analysis) [1].

The spoken language that humanity has used since its existence until today has its characteristics and structure. Natural language processing, a sub-branch of artificial intelligence, is a technique that analyzes the features of world languages and sentiment analysis. Natural language processing is the most important building block in creating the language between humans and machines. In this way, it enables textual data to be converted into the desired language in the digital environment, logical answers to questions can be given, synthesis and summary of digital texts can be made, and machines can be directed with voice commands [2]. Natural language processing technique, which is still not at the desired level in today's technology, continues to develop.

Many methods have been used in the development phase of natural language processing science. The result values of these methods, model training times, number, and diversity of data are important parameters in proving themselves in natural language processing science. Deep learning is one of the most intriguing methods in recent years. With deep learning, it is possible to create language model analysis, voice analysis, decision-making systems, visual data, and models with multiple inputs and outputs [3]. Deep learning language model analysis helps us understand emotional expressions in any language. In this way, intention analysis and emotion classification can be performed on the analyzed language. Voice is one of the emotional building blocks that carries people's emotional burden more than words. It is possible to reach the idea of a person's emotion by analyzing the voice using the deep learning method. Thus, a decision can be made by classification with deep learning. It is also possible to classify visual data with the CNN deep learning method and to obtain text from the image with the RNN method. The classification process, which has many outputs such as angry, happy, fearful, etc., is made possible by the deep learning method [4].

In this study, natural language processing methods were used to detect terror threat elements through text, audio, and image data. The Spark NLP method was applied to textual data, the LSTM method was applied to audio data, and the GRU method was applied to visual data. Each model created is aimed to detect terror threat elements. The rest of the study is summarized as follows. Section 2 includes literature studies, Section 3 includes explanations about the contents of the materials used in the artificial intelligence model and the methods used, Section 4 includes research findings, and Section 5 includes conclusions and recommendations.

2. Literature study

2.1. Sentiment analysis studies with natural language processing

Seker (2016), conducted sentiment analysis with the machine learning method in his study. It revealed the value order of words by using TF-IDF management for feature extraction before natural language processing. After the feature processing, it used the Linear Regression machine learning method to classify emotions with an accuracy of 83% in Turkish data and 74% in English data [5]. Tuzcu (2020), made a sentiment classification of user comments. He used the Support Vector Machine, Naive Bayes, and Logistic Regression methods in his study. It reached an accuracy rate of 80.93% with the Support Vector Machine method, 77.57% with the Naive Bayes method, and 84.07% with the Logistic Regression method [6]. İlhan and Sağaltıcı (2020), conducted a sentiment analysis on comments received on Twitter. They ran their models through the Support Vector Machine, Naive Bayes, and Vader, and reached the highest accuracy rate of 64% with the Support Vector Machine [7].

Yilmaz et al. (2021), performed sentiment analysis on Turkish texts with deep learning. Since the diversity of the data used is of great importance in the reliability of the model, the success of deep learning in big data has been mentioned. It has been found that deep learning provides a 40% improvement in model accuracy in big data compared to other methods such as machine learning [8]. Yılmaz and Orman (2021), carried out a sentiment analysis with comments received on Twitter during the Covid 19 period. Using Support Vector Machine and Logistic Regression methods, an accuracy rate of 75% and 74.75% was achieved, respectively. It was observed that 89% accuracy was achieved in the model made with BERT. It was stated that the accuracy of the model reached 98.13% in the training reduced sentiment analysis from sentence structure to word structure [9].

Ekim and İnner (2021), reviewed many studies conducted with natural language processing. These studies include machine learning methods, deep learning methods, and word/sentence vector creation methods. They have shown that a significant number of models have been created in sentiment analysis and opinion mining studies with natural language processing since 2017 [10]. Yurt (2015), conducted a sentiment analysis of 2000 comments taken from the virtual environment. He classified the comments into 2 groups: positive and negative. He used the TF-IDF method in his study and achieved an accuracy rate of approximately 74% [11].

Bostancı and Albayrak (2021), conducted a study on recommending personalized content by performing sentiment analysis with natural language processing. They took the data from the comments in the virtual environment and trained their models. It was stated that an 83% accuracy rate was achieved as a result of the training [12]. Polat and Ağca (2022), divided the comments made on the internet into two classes, positive and negative, using the Random Forest method. They achieved an accuracy rate of approximately 77% [13]. Atlı and İlhan (2021), conducted a study on creating an emotion dictionary with natural language processing. In their studies, they showed that 38 different emotions could be extracted using machine learning methods [14].

2.2. Other studies on natural language processing

Albayrak (2020), discussed the preparation of graduate course curricula and contents with natural language processing. Data cleaning used the TF-IDF classification method after data preprocessing. At the end of his study, he made a week distribution and obtained a table chart showing the courses and exam days that should be covered each week [15]. Toğaçar et al. (2021) used the natural language processing technique to detect fake news on the internet. They used 3171 real and 3164 fake news to train the model. They reached a very high success rate of 91.48% in the model created using the LSTM method [16].

Canım (2019), conducted a study showing the semantic closeness of words used in ancient languages. Model training was carried out using the word vector creation method of natural language processing. In the model, words used in old Turkish that are not used today are included in the dataset. In the study, word vectors were created with CBOW and Skip-gram methods, and higher performance results were obtained with CBOW [17]. Kontuk and Turan (2020) classified comments on news sites according to age groups using natural language processing science. They divided the dataset, consisting of a total of 3925 comments, into 70% training and 30% testing. In the model created by the term frequency method, a 70% accuracy rate was achieved [18].

Dayan and Yılmaz (2022), studied sound classification and sound production using natural language processing and deep learning methods. They created training models by taking various sounds from the Kaggle website using CNN, LSTM-NLP and ANN methods. They achieved the highest success in voice classification with LSTM-NLP with an accuracy rate of 91%. At the same time, they created a model that allows machines to communicate with each other and to make sounds from the outside world sound similar to each other [19]. Küçük and Arıcı (2018), studied the rapidly increasing importance of deep learning in natural linguistics. They stated the importance of natural language processing in many areas such as text classification, information extraction, question answering, and text parsing [4].

Aksoy (2021), discussed the evaluation of open-ended exams with natural language processing in his study. In his study, a 97% accuracy rate was achieved with the KNN algorithm he used for the geography course. It has been shown that this result has the highest accuracy rate among the courses [20]. Oflazer (2016), studied Turkish languages with natural language processing science. He managed to apply the sentence structure, language model and meaning extraction processes of the Turkish language using the word/vector method [21]. Delibaş (2008), discussed the process of finding spelling errors in Turkish language with natural language processing. The model was created using the root finding method. As a result of the training, a 92% accuracy rate was achieved [22].

3. Materials and methods

3.1. Proposed natural language processing methods

In the study, 3 different models were created for possible terror detection using natural language processing science. These models consist of attack detection steps from conversations or comments converted to text with Spark NLP, emotion analysis and language detection using the tone of voice feature with LSTM, and possible threat detection by converting images to text with the image caption method with GRU. These model steps are given in detail in Fig. 1.

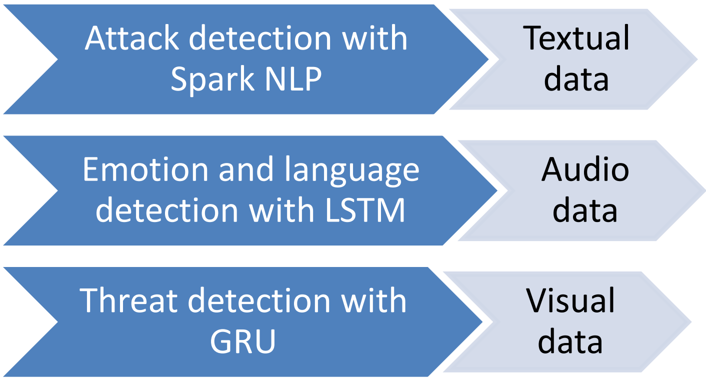

Fig. 1. Model steps.

In Fig. 1., natural language processing methods are applied for each model. Models were trained with Spark NLP and RNN (LSTM, GRU) methods. Each model was trained, and studies were carried out on the detection of terror and threat elements.

3.2. Datasets

3.2.1. Textual dataset

The textual data used in the model created with Spark NLP was prepared by the Cornell University "Automated Hate Speech Detection and the Problem of Offensive Language" department [23]. The textual dataset distribution is shown in Table 1.

Table 1. Textual dataset distribution.

Class	Number of Data
Hate	1430

Attack	19190
Safe	4163
Total	24783

In Table 1, the numbers of 1,430 hate, 19,190 attack and 4,163 non-dangerous sentences are expressed in the model. The success of offensive sentences is aimed in the model. Model training was carried out in the Google Collaboratory [24] environment.

3.2.2. Audio dataset

The audio dataset used in the model created with LSTM was downloaded from the Kaggle website [25]. Model training was carried out with a total of 1440 different sound files. Table 2 shows the audio dataset distribution.

Table 2. Audio dataset distribution.

Sentiment	Female	Male	Total
angry	96	96	192
calm	96	96	192
disgust	96	96	192
fear	96	96	192
happy	96	96	192
neutral	48	48	96
sad	96	96	192
surprise	96	96	192
Total	720	720	1440

Audio dataset: It contains 8 different emotions: angry, calm, disgust, fear, happy, neutral, sad, and surprise.

3.2.3. Visual dataset

The visual datasets used in the model created with GRU were downloaded from the Cocodataset website [26]. Fig. 2. shows a sampling of the data corresponding to index number 1 in the visual dataset. There are 5 descriptive sentences for each image, as shown in Fig. 2. There are 118,287 visual data in the training set and 5,000 visual data in the test set.

Fig. 2. Visual dataset sampling.

In the image taken from the dataset in Fig. 2., there are 5 comments about the image content and the image. It includes information that the giraffe eats trees, location information of the giraffe in the picture, family information as mother and baby giraffe, and various information on customs and environmental issues.

4. Research findings

4.1. Attack detection from textual data with Spark NLP

Before training, tokenizer, normalization, and noisy data cleaning processes were completed and a pipeline was created via Spark NLP. Training was carried out using ELMo, GloVe, and BERT, which are the most used word/sentence vector creation methods in the world. Model accuracy rates and training time values obtained as a result of training with Spark NLP via ELMo, GloVe, and BERT are given in Table 3 and Fig. 3.

Table 3. Spark NLP model accuracy-time table.

Sequence Number	Word/Sentence Method	Accuracy Rate	Training Time
1	ELMo	%84	17 minutes
2	GloVe	%85	1 minute
3	BERT	%84	5 minutes

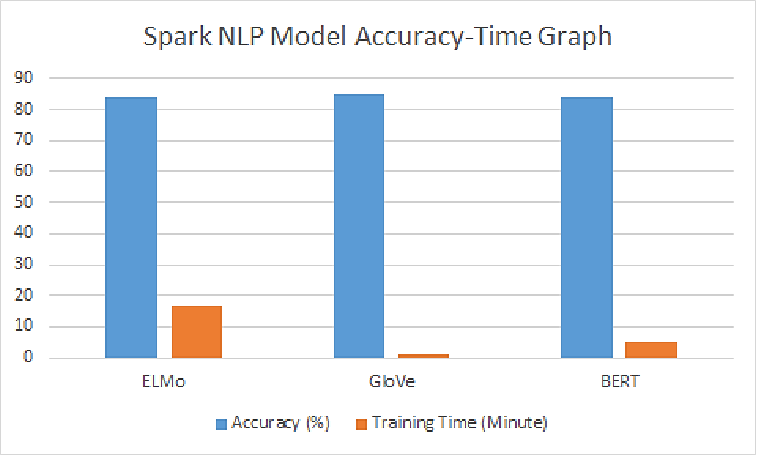

Fig. 3 Spark NLP model accuracy-time graph.

As a result of the training done with SparkNLP on ELMo, GloVe, and BERT, GloVe achieved the greatest success in detecting possible attack sentences. Although there is not much difference between GloVe and other methods in terms of accuracy success rate, GloVe managed to complete the training period in a very short time. Likewise, although there is no difference in accuracy rates between BERT and ELMo, the training time was much shorter in BERT than in ELMo. The times here may vary depending on the number of data, the characteristics of the computer on which training is performed, and the CPU-GPU-TPU structure. Normally, when these methods are trained without using Spark NLP, it has been observed that these times are much longer.

4.2. Emotion and language detecting from voice data with LSTM

Research shows that tone of voice has a more important role than words in intention analysis. It is thought that a voice with an angry, fearful, or disgusting theme is more likely to be intended to be offensive. In the created model, the aim was to find possible terror-threat intent by performing both tone of voice analysis and language detection. The LSTM method was used in the deep learning field of natural language processing in the model. During the model creation phase, the parameters were changed at each training result and the highest performance result, 74% accuracy, was achieved. Fig. 4. shows the voice analysis training and test graph.

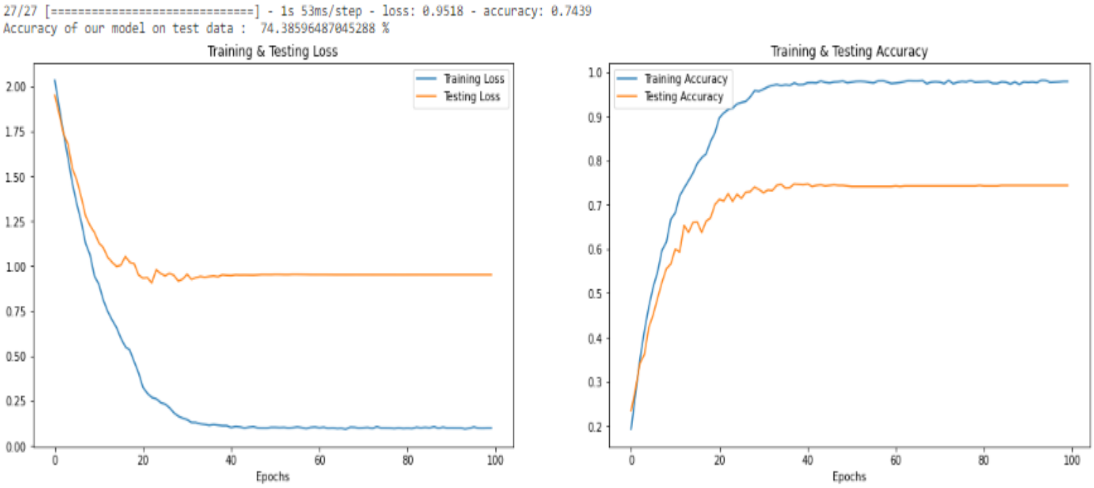

Fig. 4. Voice analysis training and testing graph.

Stabilization was achieved in the loss and accuracy graph resulting from model training carried out with 100 epochs, as seen in Fig. 4. As shown in the figure, approximately the same accuracy rate was achieved after 40 epochs of training.

Table 4. Sound prediction results.

Prediction Results	Real Voice Tag
surprise	surprise
disgust	disgust
angry	angry
angry	angry
surprise	surprise
happy	happy
fear	fear
happy	happy
happy	neutral
disgust	disgust

In the study carried out to exemplify the accuracy of the model in Table 4, correct results were achieved in all other predictions, except for the happy tone neutral error. In addition, it is thought that the detection time will be shortened by detecting the language used in the communication network in the potential threat and terror area using natural language processing science.

4.3. Threat detection from visual data with GRU

Natural language processing has enabled sentiment analysis to be performed not only on textual data but also on images. Thus, it enables the detection of possible terror-threat elements by converting the contents of visual data into textual data.

Model training was performed with GRU to detect threat elements from visual data. Model training with GRU was carried out in the Google Collaboratory environment and lasted a total of 3 hours and 17 minutes. By making changes to the parameters, an accuracy rate of 71% was achieved. An example image with a terror theme is shown in Fig. 5.

Fig. 5. Terror-themed sample image.

The picture shown in Fig. 5., taken from the Internet, was tried to be predicted at the end of model training. As a result, the prediction of "three men in uniform with guns in their hands" was successfully achieved. Although there are normally 5 people in the picture, the program detected 3 people and managed to convert their information into text.

Fig. 6. shows an example image with a threat theme. The picture shown in Fig. 6. was taken from the Ekinlaw website [27] and contains threat figures. As a result of the model's prediction of the picture, the model again produced a successful result with the prediction of "a man holding a knife in his right hand".

Fig. 6. Threat-themed sample image.

In Fig. 6., although the human figures were blurred, it still detected the human figure and successfully expressed the threat element it had. When Fig. 6. is examined carefully, it can be seen that there are other people in the background. Since the haze level of the people in the background was high, the model was not successful in detecting these people. This shows that for the success of the model after a healthy training phase is carried out with the data encoded and transferred to the digital world, clean images are needed when giving the model output.

An example image with the theme of anger is shown in Fig. 7. The picture shown in the figure was taken from the Dentiss website [28] and contains the figure of a person with a feeling of anger. The model's prediction resulted in the comment prediction "a man is talking on a cell phone". As a result of the prediction, no information was obtained about anger. Since there were no pictures and comments of anger figures in Cocodataset, the prediction was unsuccessful. It is understood from the other pictures that successful results can be achieved by training by adding external pictures and comments. Since the detection of terror-threat elements was handled textually, audibly, and visually in the study, it has been proven in the above studies that this data, which cannot be successful visually, will lead us to success through speech texts and tone of voice.

Fig. 7. Anger-themed sample image.

5. Conclusion and recommendations

In this study, models working on both text, audio, and image data were created to detect terror threats using natural language processing methods. Accuracy rates in model training have been demonstrated and method comparisons have been made.

In the first model, textual data was studied. In this model created with the Spark NLP library, 3 different word/sentence vector creation methods were used. These methods are the most used ELMo, GloVe, and BERT methods in natural language processing science. Among these methods, it was obtained from the training results that GloVe was the most successful method in the dataset, both in terms of accuracy and time. The GloVe word/sentence vector creation method managed to create the model within 1 minute via the Google Collaboratory interface, reaching an accuracy rate of 85%.

In the second model, sound data was studied. 8 different emotions belonging to 1140 different sound files were examined. Model training was carried out with the LSTM method, which was obtained by developing the RNN method. Model code blocks were written with the code menu interface of the Kaggle website, and training was carried out many times by changing the parameters for accuracy. The most successful result among the trainings was achieved with an accuracy rate of 74%.

In the third model, visual data and interpretations of these visuals were studied. The GRU method, which is also an RNN method, was used in the model. The method of converting images into text, called image caption, has been applied in the model. Model installation, training, and prediction were carried out through the Google Collaboratory interface, and an accuracy rate of 71% was achieved.

When the accuracy rates obtained from models created using natural language processing science are examined, it is seen that the most successful results are obtained from textual data. The reason for this is that the structure of textual data is more stable than the structure of audio and video data. It is also known from studies that natural language processing is more successful in textual data. Among the models created based on audio and video data, the accuracy rates of the models in the study are above average. The study shows that when all frequencies are listened to unmanned at the same time in possible terror areas with natural language processing and converted into textual data, it will be possible to detect terror-threat elements. At the same time, the possible language used by terror-threat elements can be detected. In addition, one of the objectives of the study is to show that terror-threat acts can be ended before they occur by transforming visual data into text.

In examining textual data, the studies on the Kaggle website have an average success rate of 81%, while this study has an average success rate of 85%. In examining audio data, the studies on the Kaggle website have an average success rate of 72%, while this study has an average success rate of 74%. In addition, in examining visual data, while studies have an average success rate of 65%, this study had a success rate of 71%.

In this study, the detection of terror threats using natural language processing methods, which continue to develop, was discussed. It aims to contribute to the literature on examining textual data, examining audio data, and transforming visual data into textual data in the field of natural language processing. It is planned to conduct studies using different methods and different datasets in the future.

Author contribution

The authors’ contribution rates in the study are equal.

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