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Duygu Analizinde Aşırı Öğrenme Algoritması ve Uygulamaları: Sistematik Literatür Taraması

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Anahtar Sözcükler

Duygu analizi
Aşırı öğrenme makinesi
Makine öğrenmesi

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Öz

Duygu Analizi, yapılandırılmamış metin aracılığıyla insan duygularını tanımlama ve özellik çıkarma tekniği olarak kabul edilir ve Doğal Dil İşleme ve Makine Öğrenimi yoluyla yapılır. Günümüzde birçok kurum ve şirketler bunu kullanarak müşteri veya kullanıcının özelliklerini tanımak ve ona uygun şekilde hareket etmek istemektedir. Böylece duygu analizinin önemi ve etkinliği ve kullanılan algoritmaların çeşitliliği günden güne artmaktadır. Bu algoritmalardan biri de Aşırı Öğrenme Makinesi (Extreme Learning Machine)dir. Extreme Learning Machine (ELM) algoritması, duygu analizi ve sınıflandırması için önemli bir makine öğrenimi algoritmasıdır. Bu çalışma, ELM'nin duygu analizinde kullanımına ilişkin seçilen çalışmaların kullanılan yöntem, bağlam ve uygulamaları yönünden incelendiğini gösteren sistematik bir araştırmadır. 2020 ile 2022 yılları arasında yayınlanan çalışmaların sistematik bir incelemesi, Web of Science ve Google Scholar veri tabanları kullanılarak gerçekleştirilmiştir. Literatürün ilk ve derinlemesine taranmasından sonra inceleme sürecinden 28 makaleden 10'u seçilmiştir. Makaleler, çalışmanın amacına ve araştırma sorularına göre incelenmiştir. Araştırma kapsamında yapılan inceleme sonuçlarına göre, duygu analizinde çoğunlukla ELM ile birlikte farklı metotlar kullanılmış, ELM' nin performansı iyileştirilmeye çalışılmıştır. Tedavi özetlerinin kalite analizi, sağlık, eğitim, website ürün değerlendirmeleri gibi farklı alanlarda kullanılmaktadır. ELM'nin duygu analizinde kullanımında kapsam olarak en çok sosyal medya verisi ve özellikle de Twitter platformunun kullanıldığı sonucuna ulaşılmıştır.

Extreme Learning Machine Algorithm in Sentiment Analysis and Its Applications: Systematic Literature Review

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Abstract

Natural language processing and machine learning are used to define and extract human emotions from unstructured text using a technique called sentiment analysis. Today, many organizations and companies want to use this to recognize and act accordingly on the customer or user's features. This increases the importance and effectiveness of emotion analysis and the diversity of algorithms used day by day. One of these algorithms is the Extreme Learning machine. The Extreme Learning machine (ELM) algorithm is an important machine learning algorithm for emotion analysis and classification. In this study, the method used in the ELM's emotional analysis is systematic research that shows that the context and its applications have been studied. A systematic review of the works published between 2020 and 2022 was carried out using the Web of Science and Google Scholar databases. After the first and in-depth screening of the literature, 10 of the 28 articles were selected from the review process. The articles have been reviewed based on the purpose of the study and research questions. According to the research results, different methods were used in the emotional analysis, mostly with the ELM, and ELM's performance was improved. Quality analysis of treatment summaries is used in different areas, such as health care, education, and website product assessments. ELM's use of emotion analysis has resulted in most social media data as a scope, especially the Twitter platform.

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Introduction

With the beginning of digital and web technologies, expressing and sharing ideas over the Internet has become inevitable today. Twitter, Instagram, YouTube, etc. social networking sites, have become increasingly important to users. Various users, including consumers, government, and brands, use these platforms to share promotional agreements, exchange ideas, run campaigns, raise awareness of social issues, and promote products and services. With data transmitted through such platforms, it is aimed at applying algorithms to understand consumer emotions and thoughts, analyze the views and emotions of businesses, and analyze the views and emotions of people. There are various mechanisms that are monitored to review content on social media for business analytics and emotional analysis of consumer feedback. Sentiment analysis is related to strategies that use machine learning and Natural Language Processing tools to identify and remove human emotions from unstructured text (Jindal & Aron, 2021). Any organization that intends to base choices on consumer behavior must consider emotional analysis. Learning-based and non-learning techniques can be used to categorize emotions. Compared to non-learning-based methods, machine learning-based techniques can produce better categorization results. One of the most widely used machine learning-based techniques is the Extreme Learning Machine (ELM), which consistently outperforms other gradient-based learning algorithms successfully used in a range of applications in the real world.

ELM is used in many different areas, such as medicine, robotics, and geography, due to high learning speed, providing good accuracy value, and good generalization performance. In medicine, Hu et al. (2022), propose a new model for early diagnosis and determination of the disease severity of COVID-19. In this study, a combination of kernel extreme learning machine algorithm and improved binary Harris hawk optimization (HHO) algorithm is used for prediction. The results indicate that this new model can achieve good performance. In robotics, Alcin et al. (2016), applied ELM to the operation of the robotic arm. When they compare the accuracy of the model with the Artificial Neural Network (ANN), the experimental results demonstrate that the proposed model is suitable. In geography, Hua et al. (2020), propose an optimized ELM-based model that aims to predict wind speed. Compared to other models, this new model appears to provide superior performance in predicting wind speed.

For specific classification applications, other machine learning classifiers like the Support Vector Machine (SVM) and Random Forest (RF) are also utilized. These machine-learning classifiers are utilized for binary classification issues, and it is unknown how well they perform while processing nonlinear sensitivity classification (Shafqat-Ul-Ahsaan et al., 2019).

Extreme Learning Machine

Single hidden layered forward-feed boundary networks (SLFNs) can be modeled using the ELM, which chooses hidden nodes at random and calculates the output weights of SLFNs analytically. Theoretically, this method often demonstrates high generalization performance at a very quick learning rate. Experimental results based on a few real-world and synthetic benchmarking functions approaches and classification problems, including very large complex applications, show that the new algorithm can learn thousands of times faster than traditional popular learning algorithms for forward-feeding neural networks and can produce a good generalization performance in the most cases (Huang et al., 2006).

Purpose of the Research and Research Questions

The aim of this study is to investigate how the ELM algorithm is implemented in sentiment analysis applications. Within the scope of this research, the following research questions were addressed:

RQ1: What is the application context of sentiment analysis with the ELM algorithm?

RQ2: Is there a performance difference between ELM and other machine learning algorithms in sentiment analysis?

RQ3: What are the methods used in sentiment analysis?

Method

Design of the Research

To systematically present the synthesis and interpretation of pertinent and quality work, three research questions that served as the basis for this study's design were addressed through a systematic literature review. A systematic review is a procedure that involves choosing, locating, and synthesizing pertinent research studies to present a clearer and more complete representation of the collected studies than any one study can (Gough et al., 2012). Following the detailed steps of the investigation, a systematic literature review is carried out to answer the research questions.

Selection of Relevant Literature

Web of Science, a website that provides comprehensive citation information for several databases with subscription-based access for a variety of academic studies, and Scholar, a search engine and database that searches academic articles and topics, were used for this assessment. The search keywords used for these online databases are "Sentiment Analysis" and "Extreme Learning Machine". The total number of articles identified from the database search is 16 articles on the Web of Science. The search made on Scholar yielded 1, 620 results. When searching for articles, inclusion and exclusion criteria, and searching resulted in 13 articles on the Web of Science and 15 articles on Scholar. As a result, full-text reading and analysis of each article were made depending on the purpose of the study, research questions, and whether the ELM algorithm was applied, and accordingly, a total of 10 final articles were obtained, 4 from Web of Science and 6 from Scholar.

Data Analysis

The studies that were identified and included in the research were examined in a way to seek answers to the research questions. In the research, the results related to the year of the study, keyword, method, application area, and dataset were determined as criteria. The data obtained from these criteria are entered in the table. When all assessments were completed, the data were analyzed.

Findings

In this section, the data of 10 studies examined within the scope of the research are presented for the research questions. The reviewed studies were published between 2020-2022. There are a total of 10 articles selected for the purpose of this review. The studies examined were analyzed according to the “Author”, “Year”, “Title”, “Method/Tools”, “Application/Result” and “Context/Dataset" features, and the findings are given in Table 1.

Table 1. Information of reviewed articles.

Author	Year	Paper Type	Title	Method	Application	Dataset
Samer Abdulateef Waheeb, Naseer Ahmed Khan, Bolin Chen, & Xuequn Shang.	2020	Article	Machine Learning Based Sentiment Text Classification for Evaluating Treatment Quality of Discharge Summary	Lexicon-based, extreme learning machine with autoencoder	Analyzing the quality of treatment	health and medical records
Bei Pan, Kaoru Hirota, Zhiyang Jia, Linhui Zhao, Xiaoming Jin, & Yaping Dai.	2021	Article	Multimodal emotion recognition based on feature selection and extreme learning machine in video clip	Genetic Algorithm and Extreme Learning Machine	Prediction of categorical emotions where visual and auditory signals are used as multimodal input	Emotional visual and audio dataset
Samer Abdulateef Waheeb, Naseer Ahmed Khan, & Xuequn Shang.	2022	Article	Topic Modeling and Sentiment Analysis of Online Education in the COVID-19 Era Using Social Networks Based Datasets	Extreme Learning Machine AutoEncoder (ELM-AE) and Long Short-Term Memory(LSTM)	Elimination of noise in the information	Twitter dataset
Anwer Mustafa Hilal, Badria Sulaiman Alfurhood, Fahd N. Al-Wesabi, Manar Ahmed Hamza, Mesfer Al Duhayyim, & Huda G. Iskandar.	2021	Article	Artificial Intelligence Based Sentiment Analysis for Health Crisis Management in Smart Cities	Beetle Antenna Search with Extreme Learning Machine (BAS-ELM)	Management of healthcare crisis in smart cities	Twitter dataset
Shafqat-Ul-Ahsaan, Ashish Kumar Mourya, & Parvinder Singh.	2019	Book Chapter	Predictive Modeling and Sentiment Classification of Social Media Through Extreme Learning Machine	Extreme Learning Machine	Multiclass sentiment classification of social media	Facebook dataset
P. Menakadevi & J. Ramkumar.	2022	Conference paper	Robust Optimization Based Extreme Learning Machine for Sentiment Analysis in Big Data	Robust Optimization-based Extreme Learning Machine (ROELM)	Sentiment classification in big data	Amazon product review datasets

Aijing Sun, Fan Wei, Guoqing Wang, & Yijia Li.	2022	Conference paper	Chinese Sentiment Analysis Using Regularized Extreme Learning Machine and Stochastic Optimization	Regularized Extreme Learning Machine	Chinese Sentiment Analysis	Chinese text dataset
Heyam H. Al-Baity, Hala J. Alshahrani, Mohamed K. Nour, Ayman Yafoz, Omar Alghushairy, Raed Alsini, & Mahmoud Othman.	2022	Article	Computational Linguistics Based Emotion Detection and Classification Model on Social Networking Data	Shuffled Frog Leaping Optimization (SFLO) Algorithm with Extreme Learning Machine	Recognition and classification of emotions in social networking data	Social media dataset
Mustafa Abdul Salam & Mahmoud Ali.	2020	Article	Optimizing Extreme Learning Machine using GWO Algorithm for Sentiment Analysis	Grey Wolf Optimization (GWO) with Extreme Learning Machine	Sentiment analysis of Twitter	Twitter dataset
Dr. V Chandra Sekhar, Chintalapati Sindhu Sri.	2021	Article	Predicting Cyber Bullying On Social Media In The Big Data Era Using Extreme Learning Machine	Extreme Learning Machine	Cyberbullying detection on social media	Twitter dataset

When the distribution of studies by years is examined in Table 1, it is seen that the most studies are 4 scientific studies in 2022. This is followed by 2021 with 3 scientific studies and 2019 with 3 scientific studies. Considering the number of scientific studies, it is seen that there is no regular increase in the number of studies on the application of ELM in sentiment analysis, but there are studies on this subject every year.

When the keywords used in the reviewed articles are examined, it is seen that "sentiment analysis" and "extreme learning machine" are frequently used. In addition to these keywords, similar keywords such as "emotion recognition", "emotion classification", "machine learning" and "classification" are also used in the studies.
In this study, the articles were analyzed according to the methods used. In the articles reviewed, not only the ELM algorithm but also the ELM algorithm in 8 out of 10 studies were implemented using machine learning methods such as the Lexicon-based method and optimization methods.

According to the studies examined, it is seen that 4 studies used a Twitter dataset, 1 study used a Facebook dataset, and 1 study used a social media dataset as a dataset for sentiment analysis. In the studies examined based on this, it is seen that social media is mostly used in the sentiment analysis implemented in the ELM.

Waheeb et al. (2020) developed a new sentiment analysis system using a natural language processing feature extraction method of patient discharge documents to analyze and classify treatment and diagnostic quality. In this study, the ELM method uses a metric in Eq. 1:

$$y_j = \sum_{i=1}^{\varphi} \beta_i g(w_i.x_i + b_i),\ j = 1,2,\ldots,N$$

Eq. 1. Formula of ELM

In this formula, w_i connects the input neuron and the hidden neuron in ELM and b_i is the bias of the hidden neuron. β_i provides the connection between the hidden neuron and the output neuron. This formula can be expressed as in Eq. 2:

$$y = \mathrm{H}\beta$$

Eq. 2. Expression of y with the matrix form H

Here, Moore–Penrose popularize matrix H can be represented in Eq. 3:

$$H = \begin{bmatrix} g(w_1x_1 + b_1) & \ldots. & g\left(w_\varphi x_1 + b_\varphi\right) \\ \vdots & & \vdots \\ g(w_1x_1 + b_1) & \ldots. & g\left(w_\varphi x_N + b_\varphi\right) \end{bmatrix}_{N\times\varphi}$$

Eq. 3. Moore–Penrose popularize matrix H

Statistical methods, vector space models, association rule, and Extreme Learning Machine Autoencoder (ELM-AE) are included in this system. Experimental results show that this new method is an effective technique in analyzing the quality of treatment.

This study, in which visual and auditory signals are used as input, presents a new emotion analysis system to predict categorical emotions. ELM classifiers optimized for emotion recognition are utilized. The aim here is to give different weights to the auditory modality and the visual modality based on their importance for sentiment analysis, formulated as in Eq. 4:

$$C\left(y_v, y_a\right) = \max_i \left(\beta p_v(i) + (1-\beta)p_a(i)\right)$$

Eq. 4. Formula of sentiment classification

In this formula, y_v represents the classification results of the visual modality, and y_a the auditory modality. β is the weight indicating the importance of the visual modality. $p_v(i)$ and $p_a(i)$ are implicit probability values of visual and auditory modality. This developed system was applied to three general datasets and the results were compared. Accordingly, emotion recognition results obtained by combining visual and auditory predicted emotions are superior to both the recognition of unimodality and the ranking of individual characteristics (Pan et al., 2021).

Menakadevi and Ramkumar (2022) proposed the Robust Optimization-based Extreme Learning Machine (ROELM) classifier for sentiment analysis of the large Amazon product evaluation dataset. ROELM uses natural wolf-like behavior to analyze an enormous database of reviews. ELM's single-layer hidden layer acts to improve classification performance. Indicating that classifiers trained for a particular dataset may perform poorly for other large datasets, (Menakadevi & Ramkumar, 2022) evaluated the accuracy and f-measurement performance of the proposed classifier. According to the results obtained, the proposed classifier performs better in classification than other classifiers.

In the study of Sun et al. (2022), a model with high accuracy and fast performance is developed for sentiment analysis of short Chinese texts. In this model, regularized ELM algorithm is used for classification, and the Particle Swarm Optimization algorithm is used. The extreme learning machine model used in this study is as in Eq. 5:

$$Y_m = \sum_{i=1}^{L} \beta_i G(w_i, b_i, x_j); \;\; j = 1,2, \ldots, n$$

Eq. 5. The formula of ELM

In this formula, Y_m is the output, β is the link weight matrix of the output layer and the hidden layer, and G(wi, bi, xj) is the output matrix of the hidden layer neurons. When this proposed model is compared with other models, it is seen that it has a high accuracy value and execution speed.

In Al-Baity et al. (2022) study, it is proposed a linguistic-based sentiment analysis model for sentiment recognition and classification on social network data. This model uses the ELM algorithm for sentiment analysis after making the necessary preprocessing. Then the shuffled frog leaping optimization algorithm (SFLO) is used, which changes the parameters of the ELM algorithm accordingly. In this study, the ELM formula given in Eq. 6 was used as a model:

$$\sum_{i=1}^{L} \beta_i g(w_j \cdot x_j + b_i) = t_j, j = 1,2, \ldots, N$$

Eq. 6. Formula of ELM

In this formula, w_i connects the input neuron and the hidden neuron in ELM and b_i is the bias of the hidden neuron. β_i provides the connection between the hidden neuron and the output neuron. When the experimental results are examined, it is seen that this new model outperforms other models (Al-Baity et al., 2022).

In Shafqat-Ul-Ahsaan et al. (2019) study, the ELM algorithm, which outperforms the SVM classifier and is widely preferred in classification, is used to apply sentiment analysis on the Facebook dataset. The ELM algorithm, which can present the results in categorical form, has been analyzed for the multi-class sentiment. ELM algorithm Single Layer Feed Forward Networks with activation function λ(x) and N hidden nodes can be modeled as in Eq. 7:

$$\sum_{i=1}^{\check{N}} \beta_i \lambda_i(x_j) = \sum_{j=1}^{\check{N}} \beta_i \lambda_i(W_j, b_j, x_j)$$

Eq. 7. The formula of ELM

In this equation, wj is the vector form input weight between the various input layer nodes and the jth hidden layer node, and it has the values (wj_1, wj_2,..., wj_m). β_j is the weight matrix of the jth hidden layer nodes, and $\lambda(\cdot)$ is the activation function which is a continuous nonlinear function. The ELM has the capability to approach any predicted value by minimizing the error, the expression can be edited as in Eq. 8:

$$H\beta = \tau$$

Eq. 8. Expression of the output with the matrix form H

where *H* is the output matrix of the hidden layer

$$\begin{bmatrix} h(x_1) \\ h(x_2) \\ \vdots \\ h(x_n) \end{bmatrix} = \begin{bmatrix} \lambda(w_1, b_1, x_1) & \dots & \lambda(w_m, b_m, x_1) \\ \lambda(w_1, b_1, x_2) & \dots & \lambda(w_m, b_m, x_2) \\ \vdots & \dots & \vdots \\ \lambda(w_1, b_1, x_n) & \dots & \lambda(w_m, b_m, x_n) \end{bmatrix}$$

Eq. 9. Expression of the resultant output

where β is the weight of the hidden layer and τ is the target matrix of the ELM. Experimental results show that ELM obtains better performance and accuracy compared to other machine learning classifiers.

Sekhar and Sri (2021) develop a system to predict whether there is cyberbullying in social media. In addition, (Shafqat-Ul-Ahsaan et al., 2019), the study also uses the Twitter dataset. They apply deep learning-based models, thinking that they can improve their prediction ability by using ELM techniques. As a result, it has been reached that it makes a better prediction and classification than other methods.

In the model proposed in Waheeb et al. (2022) study, the ELM algorithm and Autoencoder are used together to eliminate the noise in the Twitter data, and LSTM (Long Short-Term Memory) is included in the application in classification. In this study, the ELM method uses a metric in Eq. 10:

$$y_j = \sum_{i=1}^{\varphi} \beta_i g(w_i.x_i + b_i),\ j = 1, 2, \dots, N$$

Eq. 10. Formula of ELM

In this formula, w_i connects the input neuron and the hidden neuron in ELM and b_i is the bias of the hidden neuron. β_i provides the connection between the hidden neuron and the output neuron. This formula can be expressed as in Eq. 11:

$$y = \mathrm{H}\beta$$

Eq. 11. Expression of y with the matrix form H

Here, Moore–Penrose popularize matrix H can be represented in Eq. 12:

$$H = \begin{bmatrix} g(w_1 x_1 + b_1) & \cdots & g(w_\varphi x_1 + b_\varphi) \\ \vdots & & \vdots \\ g(w_1 x_1 + b_1) & \cdots & g(w_\varphi x_N + b_\varphi) \end{bmatrix}_{N \times \varphi}$$

Eq. 12. Moore–Penrose popularize matrix H

When the results are examined, it is seen that this proposed model achieves higher performance when compared with training test sets of different sizes (Waheeb et al., 2022).

Hilal et al. (2022) presented an artificial intelligence-based sentiment analysis system for health services crisis management in smart cities. Validation and tests are performed on the Twitter dataset. Brainstorm Optimization Algorithm (BSO) and Deep Belief Network Algorithm (DBN) are used together for feature extraction. For classification, the Beetle Antenna Search algorithm is used together with the ELM in various classes. In this study, the ELM formula given in Eq. 13 was used as a model:

$$h_j = g(W_j^i x_i^T + b_j)$$

Eq. 13. The formula of ELM

where g is the activation function, W_j^i indicates the input weight vector and b is the bias. When this formula is remodeled with the matrix below:

$$Y = H\beta$$

$$\text{where } H = \begin{bmatrix} g(W_1 x_1^T + b_1) & \cdots & g(W_L x_1^T + b_L) \\ \vdots & \ddots & \vdots \\ g(W_1 x_N^T + b_1) & \cdots & g(W_L x_N^T + b_L) \end{bmatrix}_{N \times L}, \beta = \begin{bmatrix} \beta^1 \\ \vdots \\ \beta^L \end{bmatrix}_{L \times m}, Y = \begin{bmatrix} y^1 \\ \vdots \\ y^m \end{bmatrix}_{N \times m}$$

Eq. 14. The equation of the matrix H

The resultant expression can be obtained as in Eq. 14. Experimental results show that measurements such as high classification performance and accuracy value have been achieved.

In this study, it is aimed to make a sentiment analysis on the Twitter dataset, which is one of the big social media forums where people share their feelings and thoughts. A new approach that optimizes the ELM algorithm with the Grey Wolf Optimization algorithm is presented. According to the results, it has been noted that the new hybrid model can cope with the problems of the classical ELM models and outperforms the other models compared (Salam & Ali, 2020).

Discussion and Conclusion

In this systematic literature review, the use of the ELM algorithm in sentiment analysis has been investigated in terms of the methods used and the context. In the reviewed articles, it is stated that the combination of the results with pure ELM or some other algorithms shows high performance and accuracy when compared to other algorithms. In 8 of the 10 selected scientific studies, the ELM algorithm is either modified or used in a hybrid way with other algorithms to improve its performance.

When the studies examined within the scope of the research are examined in the context of the method used, it is seen that algorithms such as Genetic Algorithms (Pan et al., 2021), Beetle Antennae Search Algorithm (Hilal et al., 2022), Shuffled Frog Leaping Optimization Algorithm (Al-Baity et al., 2022), Grey Wolf Optimization Algorithm (Salam & Ali, 2020) and Particle Swarm Optimization Algorithm (Sun et al., 2022) are also used in addition to the ELM algorithm.

When the studies are examined in the context of the scope and the dataset used, it is seen that the ELM algorithm is used in sentiment analysis in different research areas. 4 of the analyzed studies use the Twitter dataset (Salam & Ali, 2020; Salam & Ali, 2020; Sekhar & Sri, 2021; Waheeb et al., 2022), 1 of them use the Facebook dataset (Shafqat-Ul-Ahsaan et al., 2019) and 1 of them uses the social network dataset (Al-Baity et al., 2022). Based on these data, it is seen that social media, and especially Twitter, is the context frequently used in sentiment analysis.

Another finding from this research is that the basic formula of ELM was used in most of the studies. In these studies, the basic ELM model was either simply used or developed and applied. In addition, these models show successful performance in the studies examined. In addition to these, Waheeb et al. (2020) and Waheeb et al. (2022) used the same ELM model on different topics in their studies.

Wang et al. (2022), also reviewed ELM with different aspects and topics. Theoretical analysis, various improvements in the performance of ELM, and applications of ELM in different fields are given and discussed.

This study has some limitations that should be considered along with its contribution to the literature. It can be stated that there is a limitation in comparing the use of ELM in sentiment analysis, as 10 studies are suitable to be included in the study. As the ELM algorithm is applied to different topics in sentiment analysis, different results will be obtained. In addition, this study covers the years 2020-2022. This limitation can be removed if the scope year of the studies is extended, and future studies are included.

Research Ethics

The authors declare that the research does not have an unethical problem.

Contribution Rate of Researchers

The authors contributed equally to each part of this study.

Conflict of Interest

The authors declare that this study has no conflicts of interest.

Funding

The authors declare that there is no funding for this study.

The Ethical Committee Approval

This study does not require an ethics committee decision, since data in an international database open to all researchers is used, no experimental procedures have been performed on any living species, and there is no need for a data collection process.

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