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CLASSIFICATION OF CHILD GROWTH AND DEVELOPMENT DISORDERS USING SUPPORT VECTOR MACHINE (SVM)

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Abstract: *Child developmental disorders are conditions that may affect children's cognitive, behavioral, social, and communication abilities. Early identification of developmental disorders is essential to ensure timely intervention and appropriate treatment. However, the classification of developmental disorders remains challenging due to the similarities of symptoms among different disorders. Therefore, this study aims to implement the Support Vector Machine (SVM) algorithm for the classification of child developmental disorders, specifically ADHD, Autism Spectrum Disorder and Down Syndrome. This study employed a quantitative approach using a dataset consisting of 1,786 records with nine predictor attributes related to developmental symptoms. Data preprocessing was performed through missing value handling using the Most Frequent Imputation method and label encoding. The dataset was divided into training and testing sets using an 80:20 ratio. The SVM model was developed using the Radial Basis Function (RBF) kernel and evaluated using a confusion matrix, accuracy, precision, recall, and F1-score metrics. The experimental results demonstrated that the proposed SVM model achieved an accuracy of 98.88%. The classification report showed high performance across all classes, with precision, recall, and F1-score values reaching 0.99 on average. Confusion matrix analysis indicated only four misclassified instances out of 358 testing samples, while the Down Syndrome class achieved perfect classification performance. The findings indicate that the SVM algorithm is highly effective for classifying child developmental disorders and has the potential to support early identification and decision-making processes in child healthcare. The proposed model can serve as a reliable decision-support tool for healthcare professionals and parents in detecting developmental disorders based on observed symptoms.*

Keywords: *SVM, Machine Learning, Developmental Disorders, ADHD, Autism, Down Syndrome, Classification.*

Abstrak: Gangguan perkembangan anak merupakan kondisi yang dapat memengaruhi kemampuan kognitif, perilaku, sosial, dan komunikasi anak. Identifikasi dini terhadap gangguan perkembangan sangat penting untuk memastikan intervensi yang tepat waktu dan penanganan yang sesuai. Namun, klasifikasi gangguan perkembangan masih menjadi tantangan karena adanya kemiripan gejala di antara berbagai jenis gangguan. Oleh karena itu, penelitian ini bertujuan untuk mengimplementasikan algoritma Support Vector Machine (SVM) dalam klasifikasi gangguan perkembangan anak, khususnya Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), dan Down Syndrome. Penelitian ini menggunakan pendekatan kuantitatif dengan memanfaatkan dataset yang terdiri dari 1.786 data dan sembilan atribut prediktor yang berkaitan dengan gejala perkembangan anak. Tahap prapemrosesan data dilakukan melalui penanganan nilai yang hilang menggunakan metode Most Frequent Imputation serta proses label encoding. Dataset kemudian dibagi menjadi data pelatihan dan data pengujian dengan rasio 80:20. Model SVM dikembangkan menggunakan kernel Radial Basis Function (RBF) dan dievaluasi menggunakan confusion matrix, accuracy, precision, recall, serta F1-score. Hasil eksperimen menunjukkan bahwa model SVM yang diusulkan mampu mencapai tingkat akurasi sebesar 98,88%. Laporan klasifikasi memperlihatkan kinerja yang sangat baik pada seluruh kelas dengan nilai rata-rata precision, recall, dan F1-score

mencapai 0,99. Analisis confusion matrix menunjukkan hanya terdapat empat kesalahan klasifikasi dari total 358 data pengujian, sementara kelas Down Syndrome berhasil diklasifikasikan secara sempurna tanpa kesalahan. Temuan penelitian ini menunjukkan bahwa algoritma SVM sangat efektif untuk mengklasifikasikan gangguan perkembangan anak dan memiliki potensi besar dalam mendukung proses identifikasi dini serta pengambilan keputusan di bidang kesehatan anak. Model yang diusulkan dapat digunakan sebagai alat bantu pengambilan keputusan yang andal bagi tenaga kesehatan maupun orang tua dalam mendeteksi gangguan perkembangan anak berdasarkan gejala yang diamati.

Kata Kunci: Support Vector Machine (SVM), Machine Learning, Gangguan Perkembangan Anak, ADHD, Autisme, Down Syndrome, Klasifikasi.

INTRODUCTION

The rapid advancement of information technology and computer science has significantly influenced various sectors, particularly healthcare. The integration of artificial intelligence and machine learning technologies has enabled healthcare practitioners to process medical data more efficiently and accurately, supporting disease diagnosis, prediction, and clinical decision-making processes (Apriliyana et al., 2021). By learning patterns from historical data, machine learning has become a promising approach for developing intelligent systems that can assist in the early detection of various health-related conditions.

One healthcare issue that requires serious attention is child growth and developmental disorders. Child growth and development refer to a continuous process involving physical, cognitive, emotional, and social changes that occur from infancy to adulthood. Growth is generally associated with measurable physical changes in body size, whereas development encompasses broader aspects, including thinking ability, communication skills, social interaction, emotional maturity, and adaptation to the surrounding environment (Kusparlina & Warsito, 2022). Both aspects play a crucial role in determining the overall quality of life and future potential of children.

Optimal growth and development are essential for shaping healthy, productive, and socially adaptive individuals. Conversely, abnormalities or disorders in the developmental process may lead to various adverse consequences affecting academic achievement, social competence, and psychological well-being. Developmental disorders that remain undetected during early childhood may hinder learning capacity, communication skills, social interaction, and overall quality of life in the long term (Larasati et al., 2022).

Several common developmental disorders experienced by children include Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), and Down Syndrome. These conditions may be influenced by multiple factors, such as genetic predisposition, environmental exposure, prenatal conditions, social interaction, and life experiences (Habsy et al., 2024). Therefore, early identification of developmental disorder symptoms is essential to ensure that children receive appropriate intervention and support at the earliest possible stage.

Despite its importance, the identification of developmental disorders remains a challenging task. Many parents and caregivers have limited knowledge regarding the early symptoms and behavioral characteristics associated with developmental abnormalities. As a result, diagnosis is often delayed until the condition becomes more apparent or

severe. In fact, early psychological and developmental assessments are necessary to determine whether a child is developing normally or requires specialized assistance to optimize future growth and developmental outcomes (Adiputra et al., 2021).

To address this issue, an effective analytical approach is required to assist in identifying and classifying developmental disorders based on observable symptoms. Machine learning provides a potential solution through its ability to learn from data and generate predictive models capable of distinguishing different classes of developmental conditions. Such models can function as decision-support tools that facilitate early diagnosis and enable more objective and efficient assessments.

Among various machine learning classification algorithms, Support Vector Machine (SVM) has gained considerable attention due to its strong classification performance. SVM is designed to construct an optimal hyperplane that maximizes the separation between different classes, resulting in high classification accuracy and good generalization capability. These characteristics make SVM an effective method for solving a wide range of classification problems across different domains.

Numerous previous studies have demonstrated the effectiveness of SVM in classification tasks. Sugara and Subekti (2019) applied SVM for the early detection of autism disorders and reported a classification accuracy of 91%. Similarly, Monica and Sulastri (2023) utilized SVM to classify fetal health conditions using Cardiotocography (CTG) data and achieved an accuracy rate of 87%. These findings indicate that SVM is capable of identifying complex patterns in healthcare-related datasets and producing reliable classification results.

Although SVM has been successfully implemented in various healthcare applications, studies focusing on the classification of child developmental disorders remain relatively limited. Most existing research concentrates on a single developmental disorder, particularly autism, while other common disorders such as ADHD and Down Syndrome receive less attention. Consequently, there is still a need for a more comprehensive classification model capable of identifying multiple developmental disorders simultaneously.

Based on these considerations, this study proposes the application of the Support Vector Machine (SVM) algorithm for the classification of child growth and developmental disorders based on observed symptoms. The proposed model aims to classify several categories of developmental disorders, including Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), and Down Syndrome. The findings of this study are expected to contribute to the development of intelligent decision-support systems for child healthcare and assist healthcare professionals and parents in conducting early detection more accurately, efficiently, and objectively.

METHODS

Research Framework

This study employed a quantitative research approach to develop a classification model for child growth and developmental disorders using the Support Vector Machine (SVM) algorithm.

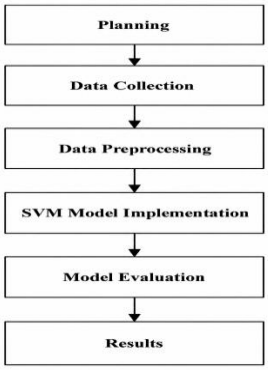

Figure 1 Research Framework

During the planning stage, the research problem and objectives were formulated. The study focused on the classification of three developmental disorders, namely Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), and Down Syndrome. Data collection was conducted using secondary data sources, observations, and literature studies related to child developmental disorders and machine learning applications in healthcare (Apriliyana et al., 2021; Habsy et al., 2024).

The collected data were subsequently processed through several preprocessing steps, including data cleaning, transformation, and normalization. Data preprocessing is essential for improving dataset quality and enhancing machine learning performance (Han et al., 2022).

Support Vector Machine Model

Support Vector Machine (SVM) was selected as the classification algorithm because of its ability to handle classification problems effectively and generate high predictive accuracy. SVM constructs an optimal hyperplane that maximizes the margin between classes, enabling the model to distinguish different categories efficiently (Cortes & Vapnik, 1995). The workflow of the proposed classification model is shown in Figure 2.

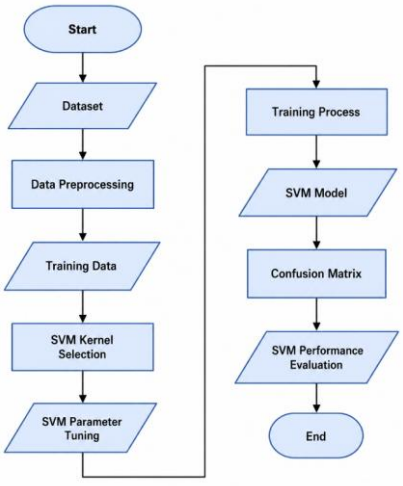

Figure 2 SVM Workflow

The process begins with dataset preparation and preprocessing. Subsequently, the dataset is divided into training and testing data using an 80:20 ratio. The training data are utilized to construct the classification model, while the testing data are used to evaluate model performance.

Kernel selection plays a crucial role in the SVM algorithm. In this study, SVM kernels such as Linear, Polynomial, and Radial Basis Function (RBF) can be employed to identify the most suitable decision boundary. Furthermore, parameter optimization involving the penalty parameter (C) and kernel parameter (γ) is performed to improve classification performance (Bishop, 2006). The selection of SVM is also supported by previous studies demonstrating its effectiveness in classification tasks. Pradana et al. (2022) reported that SVM successfully classified the Iris dataset with high performance, indicating its capability in handling multiclass classification problems.

Model Evaluation

After the training process, the generated model is evaluated using testing data. Model performance is measured using a confusion matrix, which provides detailed information regarding correctly and incorrectly classified instances (Sokolova & Lapalme, 2009). The evaluation metrics include accuracy, precision, recall, and F1-score. Accuracy is calculated using Equation (1).

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \times 100\%$$

where TP represents True Positive, TN represents True Negative, FP represents False Positive, and FN represents False Negative. A higher accuracy value indicates better classification capability. The evaluation results are then analyzed to determine the effectiveness of the SVM algorithm in identifying developmental disorders in children.

Expected Output

The output of this research is a

machine learning classification model capable of identifying child developmental disorders based on observed symptoms. The model classifies cases into three categories: Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), and Down Syndrome. The importance of early detection in child developmental disorders is supported by previous studies related to speech delay intervention among children, which emphasize the significance of early identification and treatment to improve developmental outcomes (Ritonga et al., 2024; Ritonga et al., 2024).

RESULTS AND DISCUSSION

Dataset Collection

The dataset used in this study consisted of 1,786 records representing child developmental disorder cases. The dataset contained nine predictor attributes, namely Eye Contact, Hyperactivity, Difficulty Focusing, Speech Delay, Repetitive Movements, Social Difficulties, Distinctive Facial Features, Learning Difficulties, and Impulsiveness. The target attribute was *Kelas* (Class), which consisted of three categories: ADHD, Autism, and Down Syndrome.

Table 1 Dataset Attributes

No	Attribute
1	Eye Contact
2	Hyperactivity
3	Difficulty Focusing
4	Speech Delay
5	Repetitive Movements
6	Social Difficulties
7	Distinctive Facial Features
8	Learning Difficulties
9	Impulsiveness
10	Class

The dataset contains nine predictor attributes and one target attribute used for classification. Initial data exploration showed that several attributes contained missing values. Missing values were found in almost all predictor attributes, including 21 missing values in Eye Contact, 22 in Hyperactivity, 23 in Speech Delay, and 25 in Social Difficulties. Therefore, a preprocessing stage was required before model training.

Table 2 Missing Values Before Preprocessing

Attribute	Missing Values
Eye Contact	21
Hyperactivity	22
Difficulty Focusing	8
Speech Delay	23
Repetitive Movements	17
Social Difficulties	25
Distinctive Facial Features	17
Learning Difficulties	20
Impulsiveness	18
Class	18

Data Preprocessing

Data preprocessing was performed to improve data quality and prepare the dataset for machine learning implementation. Missing values were handled using the Most Frequent Imputation strategy, where empty values were replaced with the most frequently occurring value within each attribute. This approach was selected because the majority of attributes were binary indicators represented by values 0 and 1.
The class labels were then transformed into numerical values using Label Encoding. The encoding results were:

Table 3 Label Encoding Results

Class	Encoded Value
ADHD	0
Autism	1
Down Syndrome	2

Following preprocessing, the dataset was divided into training and testing datasets using an 80:20 ratio. This partitioning allowed the model to learn classification patterns from the training data while maintaining independent testing data for evaluation purposes.

SVM Model Implementation

The classification model was developed using the Support Vector Machine (SVM) algorithm. The Radial Basis Function (RBF) kernel was selected because it is capable of handling non-linear data distributions and producing more flexible decision boundaries.
The model parameters used in this study were:

Table 4 SVM Model Parameters

Parameter	Value
Kernel	RBF
C	1
Gamma	Scale

The training process was conducted using the training dataset, after which the model generated a classification function capable of distinguishing among ADHD, Autism, and Down Syndrome cases.

Model Evaluation

Model performance was evaluated using a confusion matrix and classification metrics, including accuracy, precision, recall, and F1-score.

Table 5 Classification Performance of the SVM Model

Class	Precision	Recall	F1-Score
ADHD	0.98	0.99	0.98
Autism	0.99	0.97	0.98
Down Syndrome	1.00	1.00	1.00
Macro Average	0.99	0.99	0.99
Weighted Average	0.99	0.99	0.99

The experimental results showed that the proposed SVM model achieved an overall accuracy of 98.88%. This result indicates that the model correctly classified nearly all testing instances and demonstrates the effectiveness of SVM in identifying developmental disorders based on symptom patterns.

The evaluation results demonstrate excellent classification capability across all categories, with precision, recall, and F1-score values consistently approaching 1.00.

Result

The confusion matrix results reveal that most testing instances were classified correctly.

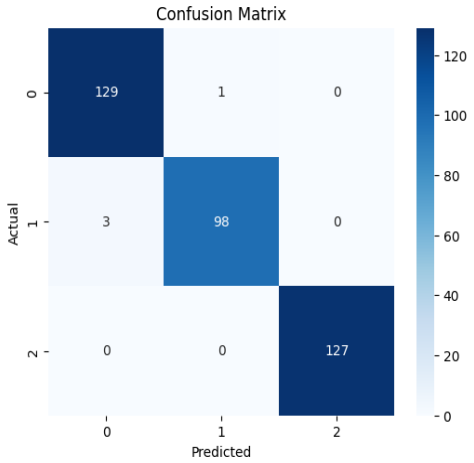

Figure 3 Confusion Matrix of SVM Classification Results

As shown in Figure 3, the majority of testing instances were successfully classified into their respective classes. A total of 129 ADHD cases were correctly classified as ADHD, while 98 Autism cases were correctly identified as Autism. Similarly, all 127 Down Syndrome cases were classified correctly, indicating excellent model performance for this category.

Misclassification occurred only in a small number of instances. Specifically, one ADHD case was incorrectly classified as Autism, while three Autism cases were misclassified as ADHD. These errors may be attributed to similarities in behavioral symptoms shared by both disorders, such as attention difficulties, learning challenges, and social interaction problems.

No misclassification was observed for the Down Syndrome category, suggesting that the model successfully learned the distinctive characteristics associated with this disorder. Overall, the confusion matrix demonstrates that the proposed SVM model achieved highly

accurate classification performance, which is consistent with the overall accuracy score of 98.88%.

Discussion

The experimental results demonstrate that the Support Vector Machine (SVM) algorithm is highly effective for classifying child developmental disorders. The model achieved an accuracy of 98.88%, indicating that the selected features successfully captured the characteristics associated with ADHD, Autism, and Down Syndrome.

The classification report showed high precision, recall, and F1-score values across all classes, with average scores reaching 0.99. These results indicate that the model performed consistently and was able to correctly identify most instances in the dataset. Furthermore, the confusion matrix revealed only four misclassified cases out of 358 testing samples, confirming the robustness of the proposed model.

The Down Syndrome class achieved perfect classification performance, with all testing instances correctly identified. In contrast, a small number of misclassifications occurred between ADHD and Autism. This may be attributed to the similarity of behavioral symptoms shared by both disorders, such as attention difficulties, learning challenges, and social interaction problems.

Overall, the findings indicate that the SVM algorithm can effectively support the early classification of child developmental disorders. The high accuracy and low misclassification rate demonstrate the potential of SVM as a reliable decision-support tool for identifying developmental disorders based on observed symptoms.

CONCLUSION

This study successfully implemented the Support Vector Machine (SVM) algorithm for the classification of child developmental disorders, namely ADHD, Autism, and Down Syndrome. Based on the experimental results, the proposed model achieved an accuracy of 98.88%, indicating excellent classification performance.

The findings demonstrate that SVM can effectively classify developmental disorders using symptom-based attributes. Therefore, the proposed model has the potential to support early identification and decision-making processes related to child developmental disorders.

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