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Article

Exploration of piano performers' music performance status and psychological health assessment based on data mining and biomechanics

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Abstract: The mental, physical, and social features of health are all essential for overall comfort. It impacts the way individuals' behavior themselves and works in day-to-day life, which affects their capacity to manage stress, communicate with someone else, and make decisions. For pianists, supporting high performance status entails not just technological mastery but also the capacity to handle physical and mental stresses. The study aims to evaluate the connection between the music performance level of pianists and psychological health based on novel data mining and biomechanics. In this study, a novel Drosophila Food Search refined support vector machine (DFS-RSVM) is proposed to evaluate the psychological health of piano performers. Psychological health factors, including stress, anxiety, and mental health focus, are related to piano musical performance. The study collected biomechanical data and sensor data correlated to posture, hand activities, muscle activity, and finger force. The data was preprocessed, utilizing normalization for the gathered data. Discrete wavelet transforms were applied to the features extracted from the dataset. The outcomes exposed the important relations between biomechanical stressors throughout piano performance and mental health, emphasizing the need for a suspicious strategy for mental health concerns. The results demonstrated the DFS-RSVM achieved superior performance and enhanced the health and performance of musicians, contributing to improved support for their physical and psychological well-being compared to other existing algorithms.

Keywords: piano performers'; music performance status; psychological health; Drosophila Food Search Refined Support Vector Machine (DFS-RSVM); biomechanics

1. Background

Mental health plays a vital role in the overall well-being, surrounding emotional and mental environment, such as piano performers; the communication among mental health and efficiency is mainly significant. Musicians often face unique stress that can drastically affect their psychological level, influencing not only their capability to manage stress but also their aptitude to conserve focus, creativity, and technical accuracy throughout performance [1]. Research has shown that mental health problems, including anxiety and performance-related stress, can destructively affect a musician's performance quality, leading to diminished outcomes and even a career-threatening situation like performance anxiety [2]. In the kingdom of piano performance, achieving and at the back peak level involves a multifaceted interaction of technological skill and psychological flexibility. Pianists must navigate the stress of complex composition, often under the investigation of audiences and critics. The mental focus required to execute a demanding piece can create an environment ripe for psychological stress. Furthermore, the physicality of piano playing surrounding posture, hand movements, muscle activity, and finger dexterity add another layer of complexity. Poor biomechanics or corporeal strain can exacerbate psychological stress, leading to a cruel cycle where substantial uneasiness impacts mental health, which in turn affects performance capability [3]. The mental health issue of music performance anxiety (MPA) is common among musicians, whether professional or amateur. Deep and ongoing anxiety associated with performing musically is the definition. A range of physiological, behavioral, affective, and cognitive symptoms are associated with MPA, and they can impair performance and cause discomfort on both a personal and professional level [4]. The phenomena known as MPA occur when performers reveal personal details to a crowd. In general, MPA is defined as a state of excitement that, at its best, can improve performance while simultaneously causing a range of undesirable stress-related symptoms. It was discovered that the size or makeup of the crowd, the degree of consumer demand, and the evaluation of the event's importance all had an impact on the amount of MPA that occurred [5].

One of the most widely used mediums for human expression and communication is music, which is utilized by people of all ages and cultural backgrounds. The majority of people have common activities that include singing, playing, listening to music, and producing [6]. People have employed music as a healing technique since ancient times. Many studies have examined the benefits of music therapy in treating a range of conditions, including mental health issues. Because of this, music students can feel less depressed, anxious, or stressed out than other undergraduates. The listener's attention is captured and maintained by music, which activates and uses a variety of brain regions. A person's skills are reflected in music. Time is arranged in a way that is understandable to humans, which makes music a powerful memory booster. Numerous studies have demonstrated a connection between musical training and cognitive function [7]. Comprehending the psychological aspects of adult music education is a significant and contemporary problem since educational establishments are beginning to evaluate and assist students' welfare, a procedure supported in some cases by legal regulations. Chilean public policy encourages institutions to set up systems of support and equalization for students beginning their teaching careers [8]. In colleges and universities, music education has not gotten enough attention while being a crucial component of high-quality education. Even though most music teachers have very simple jobs, there aren't many demands on their time or in their professional growth. However, many colleges and universities face significant challenges in promoting professional titles for music teachers, in addition to providing insufficient protection in terms of educational resources. Most college music instructors struggle to make an impression on their pupils. These all put a psychological strain on college instructors [9]. By integrating biomechanical and psychological data, it hopes to identify significant correlations that reveal how physical demands during piano performance can impact mental being. The insights gained from the research have the potential to inform preventive strategies aimed at enhancing the mental health of piano performers, providing a framework for training programs that not only focus on technical skill development but also incorporate mental health support. Ultimately, the findings seek to contribute to a holistic understanding of musician health, offering pathways to improve both physical performance and psychological resilience in piano players [10].

1.1. Research objective

The study's main goal is to elaborate how piano performance status and their psychological health utilize original data mining technique and biomechanical analysis. Particularly, the investigation aims to evaluate the way psychological factors such as stress, anxiety, and mental health issues center influence presentation, while employing a novel DFS-RSVM to examine biomechanical data, including posture, hand movements, muscle activity, and finger force. Through the examination, the study seeks to distinguish important correlations that could inform defensive strategies for attracting the mental and physical well-being of piano performances.

1.2. Key contribution

- Study introduces the DFS-RSVM as a novel analytical tool for assessing the psychological health of piano performance, offering a unique approach with biomechanical analysis. The research employs comprehensive pre-processing methods, including data normalization and feature extraction using discrete wavelet transforms.
- These techniques enhance the quality and interpretability of the biomechanical data, enabling a more accurate assessment of the relationship between psychological health and performance. The study provides valuable insights into how physical posture and movements can influence mental well-being, advancing a better comprehension of the relationship between musicians' minds and bodies.
- The findings highlight significant correlations between psychological stressors and performance status, resulting in the creation of focused preventive techniques and interventions meant to enhance piano pianists' physical and emotional well-being and, eventually, their overall performance quality.

1.3. System overview

The structure of the article is as follows: Part 2 provides literature; Part 3 provides an extensive methodology; Part 4 examines the experiment's results; and Part 5 concludes the study.

2. Literature review

MacAfee and Comeau [11] examined the relationships that developed among five teenagers about MPA, performance quality, self-efficacy, and behavioral anxiety. The results of a beneficial self-examination self-modeling technique for young performers were also examined. Although many musicians view MPA as a serious issue, there was a paucity of research on the psychobiological and performance-related implications of MPA [12]. The objective was to determine whether the general MPA level of musicians influences the psychobiological reactions and performance quality changes that occur when they perform in public compared to private settings, using the bio-psychosocial paradigm of challenge and threat as a theoretical framework. The challenge and threat paradigm stated that when people perceive more resources than demands in a performance setting, they are in a challenge state. Conversely, when people perceive more demands than resources, they are in a threat state. Osborne et al.

[13] examined the emotional objectives that musicians pursue when playing. Due to the crippling nature of performance anxiety, both academics and the general public often believe that the emotion should be suppressed. However, new insights from the emotional literature indicate that people could intentionally want to increase their fear to improve performance.

While playing their instruments, brass players were subject to significant musculoskeletal strains in [14]. These strains could be measured using a variety of methods, which also supports the application of focused therapy. Reviewing previous research on evaluations utilized in quantitatively based investigations on the examination of brass player musculoskeletal loads was the goal of the investigation. Many post-secondary music students experience physical and psychological problems associated with their music; numerous studies indicate that the frequency was more than 70% as described in [15]. However, there is currently disagreement on appropriately validated tests for the population. To determine whether Canadian post-secondary music students could benefit from using an assessment instrument created for German longitudinal research, pilot research was conducted to assess and contrast the health of with and without music students. To ascertain their threshold for pain, range of motion, and core strength, both groups filled out questionnaires and underwent physical tests. Christakou et al. [16] evaluated motor imagery's efficacy as a practice tool in situations where practicing on a piano was physically impossible. Musculoskeletal conditions associated with upper limb playing force musicians to take occasional breaks from activity. Concern for the well-being of music students has grown as research indicates that up to 50% of novices experience pain or anxiety associated with playing. The long-term study sought to assess students' health conditions, health-related mindsets, behaviors, expertise, abilities, and coping mechanisms both when they first enrolled in a music school and when the second year ended [17].

Li et al. [18] examined the big data system's effects on pianists' mental states during performances and found that the program improved the psychological quality of the players. There have been piano performances for hundreds of years, and they are becoming more popular nowadays. Improved performing and presentation abilities were essential for pianists. Musgrave [19] examined the two opposing theories regarding music and well-being. While the second believes that pursuing a profession in music could be harmful, the first believes that practicing music was beneficial for one's mental and emotional well-being. The apparent paradox was important because normative sociological guidelines that encourage music-making were being promoted by nonprofit organizations, social enterprises, advocacy organizations, educational organizations, administrations, and international organizations, whereas the settings that provide clear evidence of the clinical findings that link music to well-being were being removed. The connections between these constructs were investigated in the study [20]. MPA was a prevalently detrimental occurrence in the careers of musicians. One effective strategy to stop MPA was mindfulness. Nevertheless, the connections between MPA and mindfulness were rarely investigated in conjunction with other pertinent attention or emotion-based categories (such as self-consciousness or negative affect).

Musicians have pointed out that MPA was a highlighting issue; however, few attempts have been made to investigate its impact in terms of diverse performances in public and private domains. The challenge and threat paradigm supports theory of musicians' reactions, however, the interactions between the psychological factors such as the mindfulness and emotional regulation were not explained in details. The biomechanics evaluation on pianists should also be examined because of the lack of data on its effects to the psychological well-being and the result on performance level. It was also noted that there is a scarcity of standardised procedures in measuring the health and wellbeing of post-secondary music students, therefore calling for improved identification of the heterogeneous health issues of the populace in question. This could potentially result in improved interventions and assistance provided to musicians, based on the results of the study and the enhancements in addressing the gaps in the field of MPA. The present study addresses the gaps by integrating advanced data mining technique, the DFS-RSVM, with biomechanical analysis to produce a valid assessment of musician's psychological health and performance. DFS-RSVM helps researchers to easily explain multiple correlations between various psychological factors, performance environments and physical load due to its ability to analyze large dataset. It led to a greater understanding of the state of musicians' health and the orientation of guide activities towards enhancing performers' results.

3. Proposed system

Initially, data is collected from a piano player's hand movements, muscle activity, and finger force using biomechanical sensors deployed in the smart piano, then Z-score normalization used to remove the interference in the sensor data to standardize the data, ensuring consistent scale across features. Discrete Wavelet Transform (DWT) is applied for feature extraction, capturing time-frequency characteristics from the sensor data. The extracted features, combined with biomechanical data, are fed into a Drosophila Food Search Refined Support Vector Machine (DFS-RSVM) for classification. This optimized model aims to assess performers' psychological health and music performance status accurately and **Figure 1** represent the methodology flow of study.

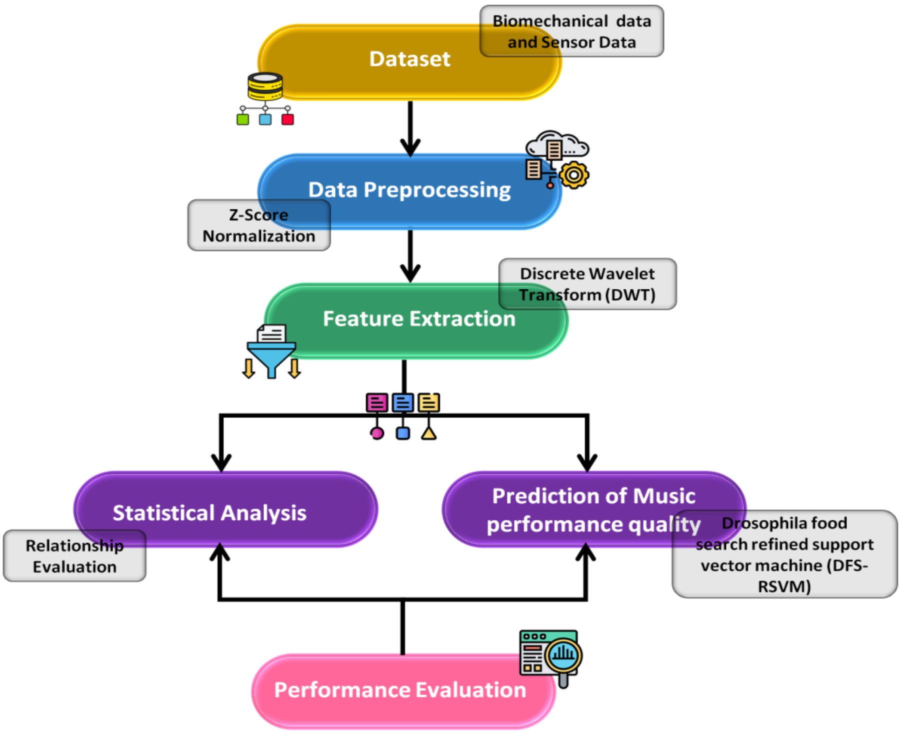

Figure 1. Diagram of proposed methodology.

3.1. Data preparation

Study involved a total of 150 participants, comprising 35 beginners, 70 intermediates, and 45 advanced pianists, between the ages of 18 and 45. Seventy men and eighty women made up the gender distribution, who engaged with various types of music such as melody, pop, and classical. Participants were assessed on their stress and anxiety levels, revealing that 45 experienced high stress, 35 faced high anxiety, and 30 reported significant mental health challenges. Biomechanical factors, including posture, hand movements, muscle activity, and finger force, were also evaluated, indicating that 40 participants exhibited poor posture and 25 demonstrated high muscle activity the dataset integrates sensor-based biomechanical data and emotional metrics from piano players performers. Biomechanical sensors capture physical parameters like hand movement, posture, and muscle tension during performances, offering insights into physical stress and fatigue. Emotional data is derived from self-reports or physiological indicators, such as heart rate response, reflecting performers' psychological states. These datasets composed help analyze the interplay between physical performance and emotional well-being. By combining both data types, the study aims to identify patterns of emotional stress or flow states, enhancing understanding of that biomechanics and emotions influence musical execution and psychological health. During performance, as shown in **Table 1**. The comprehensive analysis highlights the intricate relationship between psychological well-being and musical performance, emphasizing the need for tailored interventions in music education and performance settings. The purpose of data mining is to discover patterns, relationships and insights from large sets of data through various techniques and algorithms.

Table 1. Piano music performance status and psychological health assessment.

Category		**No. of. participants**
Participant types	Beginner	35
	Intermediate	70
	advanced	45
Type of music	Melody	25
	Pop	55
	Classical	70
Stress level	High	45
	moderate	60
	Low	45
Anxiety	High	35
	moderate	50
	Low	65
Mental health	High	30
	moderate	80
	Low	40
Posture	High	40
	moderate	55
	Low	55
Hand movements	High	20
	moderate	75
	Low	55
Muscle activity	High	25
	moderate	65
	Low	60
Finger force	High	30
	moderate	55
	Low	65

3.2. Pre-processing using *Z*-score normalization

The normalization is well-suited for the adaptive control framework of physical health, as it effectively handles outliers and scales features, ensuring consistency across diverse data inputs.

The statistical normalizing method addresses the problem of outliers. The studied feature's values mean and standard deviation are used to modify the feature values. In particular, the principles for the characteristic beneath contemplation are distorted into clean normalized values by Equation (1).

$$\nu' = \frac{\nu - \mu}{\sigma} \tag{1}$$

where σandμprovide the selected feature's average and standard deviations. When utilizing the approach, principles that are precisely equivalent to the average are interpreted as zero, values above the average emerge as positive numbers, and values below the average appear as negative statistics.

3.3. Extract features using discrete wavelet transform (DWT)

A discredited wavelet basis and a finite-length sequence are the two bases on which a collection of inner products represents the DWT mathematically. Wavelet transform coefficients are produced by each inner product. Consequently, the DWT can be written as Equation (2).

$$We(i,l) = \sum_{n=0}^{N-1} e(m).\psi_{i,l}^{*}(m) \tag{2}$$

where $e(m)$ is a length M-wise sequence; $We(i,l)$is a DWT coefficient; in equation (3),

$$\psi_{i,l}(m) = \frac{1}{\sqrt{s_0^i}}\psi(\frac{m - T_0^i.l}{T_0^i}) \tag{3}$$

Wavelet basis that has been discredited; andT_0^i are the scale and translation parameters, respectively, that have been discretized. The complex conjugate is indicated by the superscript. For a$\psi\ (m)$ DWT that is dyadic. When the DWT is applied, the number of channels or spectral band$e\ (m)$ corresponds to a hyperspectral signal. Considering that a large number of spectral bands with similar bandwidth and spacing are produced by the sampling technique used. It should be noted that the DWT can provide both a global and a detailed view of the input hyper-spectrum signal because the translated and scaled forms of a mother Fourier make up the wavelet foundation.

Wavelet detail coefficient D_i is the output of the high-pass branch; while the wavelet estimate coefficients C_i function as the low-pass branch's outputs. Up until a maximum scale is reached, iterative wavelet decomposition is conceivable. The maximum scale is defined by the wavelet basis length and the signal length.

$$C_{i+1}(j) = \sum_{k=0}^{K-1} H(k).D(2.j+1) \tag{4}$$

$$D_{i+1}(j) = \sum_{k=0}^{K-1} H(k).D_i(2.j+1) \tag{5}$$

3.4. Evaluation variables

By using the evaluation parameters, the performance of the study conducted on piano music performance status and psychological health assessment is predicted. The study implements variables such as stress, anxiety, muscle strength, mental health, and hand movements. These variables and consecutive formulas guide in quantifying the experiment conducted in the research. In addition, it also provides insights on how better each performance technique helps to improve learning. **Figure 2** delivers the evaluation metrics involved in the suggested study to evaluate the efficacy.

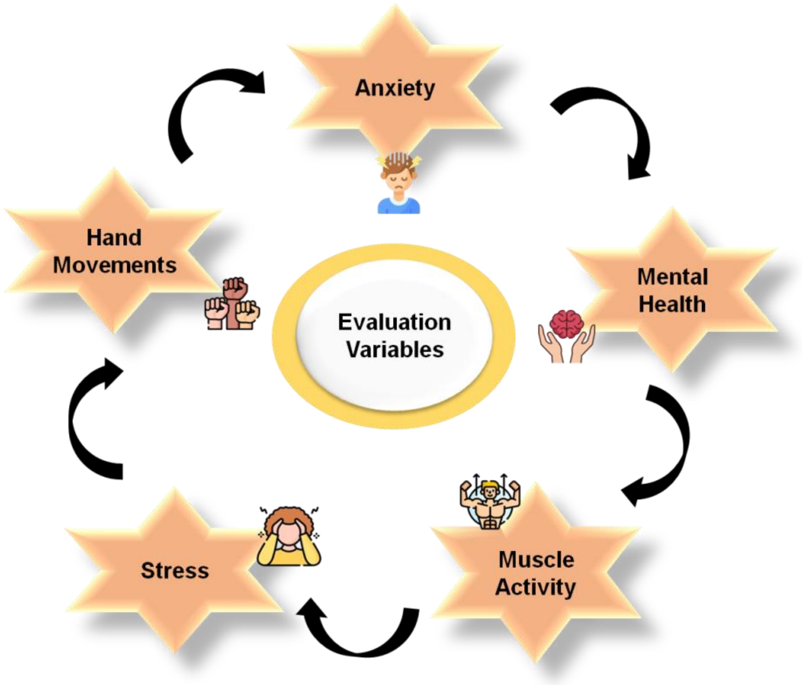

Figure 2. Evaluation metrics.

Stress: It is referring to the mental and emotional stress performed in accordance to demanding situation. It may have physical implications by leading to bodily exhaustion, anxiety, poor concentration and other factors which erode health and efficiency.

Anxiety: It is a mental illness that is characterized by anxiety, fear or trepidation. Some expressions are increase in pulse rate, fidgeting, muscle rigidity, which can be a challenge to the normal activities, and improve or worsen the mental health.

Muscle strength: It means the highest level of force which any muscle is capable of producing at one time. It is important for the whole physical well-being and results in improved ability to take part in certain tasks or sports, increases balance, coordination and decreases chances of getting an injury.

Mental health: Psychological, social and mental health that determines how persons in a society think and act are a part of it. Stress management, people's relations, and effective decision-making ability that is required for day-to-day performance and general well-being demands proper sleep.

Hand movements: This is the manner in which muscle groups enable activities such as conducting, playing an instrument or typing. They are unsuppressed essential components, and the one that involves intricate manipulation with fingers – dexterity, precision, and speeds are topical for performance.

3.5. Statistical analysis

Therefore, the proposed study has aimed to test the effectiveness of traditional training, piano and music performance status, and the psychological health assessment of the participants using data and biomechanics mining through two kinds of statistical analyses. All the implementation uses the statistical package for the social science (SPSS) which evaluate and summarize the input data. Here are listed just a few of the multiple statistical analysis available:

Multiple regressions: It is used to test the relationship between one or more independent variable and one dependent variable. Identification of a relationship between fluctuations in the independent factors and fluctuations in the dependent variables is useful. Decide on vital factors and predict the result employing the predictor variables in order to ascertain their coefficients within the overall formula.

Descriptive analysis: It was designed to give simple descriptions about the main features of a given set of data. In addition to that, the metrics create an opportunity of revealing the pattern, variation and distribution of variables such as mode, median, mean, SD and range. Descriptive analysis must be conducted in order to fully examine data prior to conducting more intricate work as it provides information obviously and without complication to show patterns and trends to even the researchers themselves.

3.6. Classification using Drosophila Food Search Refined Support Vector Machine (DFS-RSVM).

Classification using DFS-RSVM combines the optimization capability of the DFS algorithm with the robust categorization power of RSVM. DFS-RSVM enhances the model's capability to navigate complex search spaces, optimizing the selection of hyperparameters and feature weights. By refining the RSVM's decision edge, DFS-RSVM effectively handle high-dimensional data, outliers, and noise, making it a powerful tool for diverse categorization tasks across domains such as biomechanics, psychology, and big data analytics.

3.6.1. Refined Support Vector Machine (RSVM)

When it comes to solving different classification problems like pattern recognition and speaker identification, RSVM is one of the most potent classifiers. Finding the optimum hyperplane to maximize the margin between classes is the idea behind RSVM.

This **Figure 3** illustrates the emotional clustering of piano players performers, segmented into two distinct states W1 and W2 based on data mining techniques. The yellow diamonds represent performers experiencing positive emotional states, possibly linked to peak performance or flow. In contrast, the gray circles signify individuals undergoing negative emotional conditions, such as stress or anxiety. Biomechanical data likely contributes to the differentiation, showing variations in posture or physical tension during performances. W1 and W2 indicate shifts in psychological states across different performance stages, reflecting the dynamic relationship between emotional well-being and musical execution. Understanding these patterns helps in assessing performers' psychological health for improved interventions.

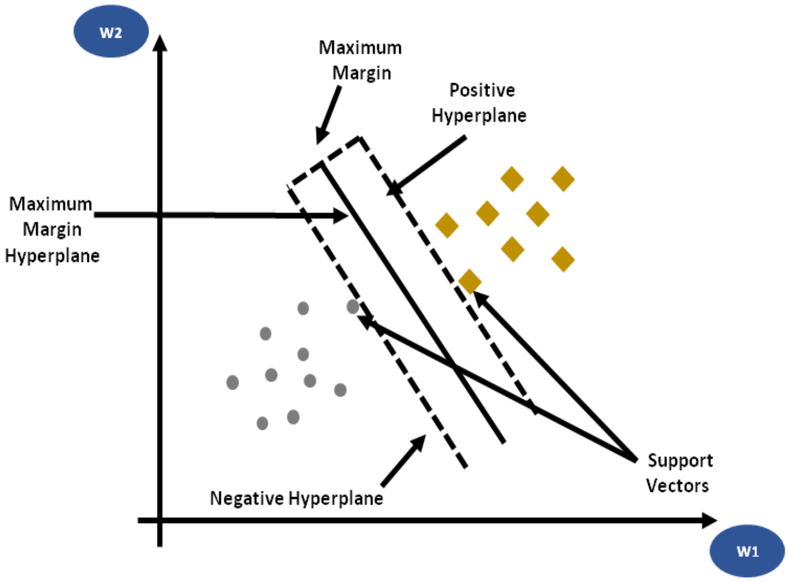

Figure 3. Diagram of RSVM.

The hyperplane is used to divide data sets into groups according to different classes. Equation (6) defines a hyperplane.

$$G = \{w | x^S w + a = 0\} \quad (6)$$

Where $x,\ a,\ and\ w$ stand for weight, bias, and data point, in that order. Equation (7) can be used to calculate the distance between a point w and a hyperplane.

$$\text{Distance} = \frac{|X^s w + A|}{||w||} \quad (7)$$

By maximizing the distance to the nearest data points from both classes, an ideal hyperplane can be identified.

It employed the one-against-one strategy for RSVM multi-classification in the investigation. To extend RSVM for a multi-class classification problem, one-against-one methods and several binary classifiers were utilized.

3.6.2. Drosophila Food Search optimization (DFS)

The DFS optimization was developed based on the feeding behaviors of the fly known as Drosophila melanogaster. Due to its extensive genetic history and superior sensory system, which includes taste and smell, D. melanogaster is superior, as shown in **Figure 4**. Drosophila has olfactory sensors that detect a wide variety of food sources and their wafting scents. Initially, once the sources are identified, the gustatory receptors (GRs) found in the proboscis's exterior sensilla ascertain the sources' preferences for food. The signal is then sent to the exterior sensilla, which reports on whether or not the item is permitted in the digestive tract. G-protein coupled receptors (GPCRs) and the internal sensilla are the ones that identify objects outside the cell and turn on the signal route. Every food source molecule function as a ligand, and the concentration of the ligand affects the GPCR's affinity for ligand-binding proteins. In the event of a high concentration, GPCR will activate and communicate with the brain's SOG area through the nervous system. The SOG area signals the proboscis to eat when the signal input is higher because food sources have a high preference ability. Then they start moving towards the food.

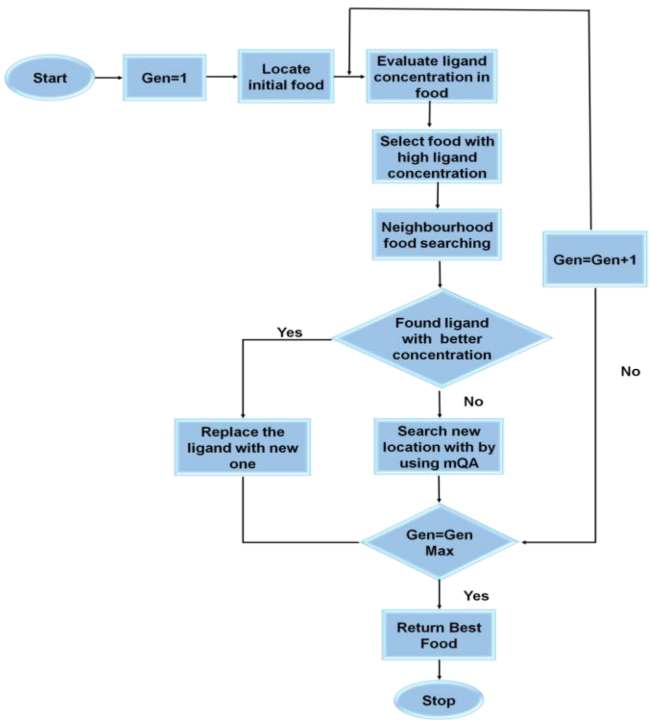

Figure 4. Flow diagram of DFS.

The steps listed here form the foundation of the basic Drosophila optimization method.

Phase of Initialization: To begin the search, the swarm location is randomly initialized in Equations (8) and (9).

$$W_0 = InitW\_axis \tag{8}$$

$$Z_0 = InitZ\_axis \tag{9}$$

Assignment Phase: Use apheresis to look for food by assigning random directions and distances in Equation (10).

$$W_j = W_0 + randValueZ_j = Z_0 + randValue \tag{10}$$

Phase of evaluation: calculate the separation between the food source and the source in Equation (11).

$$Dist_j = \sqrt{W_j^2 + Z_j^2} \tag{11}$$

The smell concentration judgment value T will be computed based on the estimated distance in Equation (12).

$$T_j = 1/Dist_j \tag{12}$$

Substitution Phase: Using the smell concentration judgment value T as an input, determine the scent concentration of each drosophila location in Equation (13).

$$Smell_j = fitnessfunction\ (T_j) \tag{13}$$

Phase of Identification: Currently, use Equation (5) to determine the optimal scent concentration in Equation (14).

$$[bestSmell_{BestIndex}] = \max(smell) \tag{14}$$

Phase of Selection: Fruit flies will currently utilize their vision to locate the finest food sources in Equations (15) and (16).

$$W_0 = W\ (BestIndex) \tag{15}$$

$$Z_0 = Z\ (BestIndex \tag{16}$$

After classification using DFS-RSVM, the model's performance can be evaluated through various metrics to assess its effectiveness and reliability, as shown in Algorithm 1.

Algorithm 1 DFS-RSVM

```
1: Initialize Parameters:
2:   Define hyperparameters for RSVM
3:   Set DFS parameters (population size, iterations)
4: Initialize Drosophila Swarm:
5:   For each fly i in the swarm:
         W[i] = InitW_axis
         Z[i] = InitZ_axis
6: Evaluate Fitness of Swarm:
7:   For each fly i in the swarm:
         Dist[i] = sqrt(W[i]^2 + Z[i]^2)
         T[i] = 1 / Dist[i]
         Smell[i] = fitness_function(T[i])
8: Identify Best Food Source:
         bestSmell_BestIndex = max(Smell)
9:Update Swarm Position:
         W[0] = W[bestSmell_BestIndex]
         Z[0] = Z[bestSmell_BestIndex]
10: Perform RSVM Classification:
11:   Train RSVM model using selected hyperparameters
12:   Optimize hyperplane using DFS to maximize margin:
13:     For each class pair (class_a, class_b):
14:       Find hyperplane defined by w and a using Equation (6)
15:       Calculate distance using Equation (7)
16: Evaluate Model Performance:
17:   Use metrics (accuracy, precision, recall) to assess classification effectiveness
18:   Analyze results for practical applications (psychological health profiles, biomechanical factors)
19: Output Results:
20:   Present findings and insights for further research and intervention strategies
```

The results can be utilized for various practical applications, such as identifying specific psychological health profiles of musicians or assessing the impact of biomechanical factors on performance. The information can inform targeted interventions, such as personalized training programs or mental health support strategies, aimed at enhancing the overall well-being and performance of individuals; additionally, the insights gained from DFS-RSVM classification can guide further research in related fields, encouraging a better comprehension of how physiological and psychological elements interact in performance situations.

4. Result

4.1. Experimental setup

An Arduino Uno for sensor data acquisition, integrated with biomechanical sensors (FSR 402, TCRT5000, MPU-6050) connected via USB. Data preprocessing and SVM classification were conducted using Python 3.11.4 on Windows 11, running on an 11th-generation Intel® Core™ i7 processor with 16 GB of RAM. Key Python libraries included NumPy for data normalization, and scikit-learn for performance classification, SciPy for feature extraction, and Pandas ensuring real-time processing and feedback.

4.2. Parameters setup

The hypermeters for DFS-RSVM methods are described in **Table 2**.

Table 2. Parameters setup.

Hyperparameters	**Typical values**
Swarm size	20, 50, 100
Initialization Range	Problem-specific (based on date range)
Random value range	0.1, 0.5, 1.0,
Smell concentration fitness function	MSE, Classification accuracy
Best index update frequency	1, 5, 10
Kernal function	RBF, Polynomial, Linear
Regularization parameter	0.1, 1, 10, 100
RSVM Gamma	0.01, 0.1, 1.0
Maximum iterations	1000, 5000, 10,000
Convergence tolerance	0.001, 0.0001
Learning Rate	0.001, 0.01, 0.1
Cross-validation folds	5, 10

4.3. Performance evaluation

The category explains the results produced by implementing the approach using different statistical techniques. Discussion for outcomes procured for each statistical technique is also explained.

4.3.1. Results obtained by using multiple regression

Initially, multiple regressions were performed in the study to calculate the effectiveness of participants before and after the intervention of the experiment. **Table 3** displays the test findings for several regression-based within-group comparisons.

Table 3. Multiple regression.

Metric	Unstandardized coefficient (B)	Standardized coefficient (β)	*T*-value	*P*-value	95% confidence interval
constant	10.50		5.25	0.000	[8.50, 12.50]
Stress	−0.45	−0.30	−4.25	0.001	[−0.65, −0.25]
Anxiety	−0.60	−0.35	−5.10	0.000	[−0.80, −0.40]
Muscle activity	0.30	0.25	3.15	0.002	[0.10, 0.50]
Hand movements	0.25	0.20	2.90	0.004	[0.05, 0.45]
Mental health	0.50	0.40	4.75	0.000	[0.30, 0.70]

The results from the multiple regression analysis shed light on the relationships between various independent variables such as stress, anxiety levels, muscle activity, hand movements, and the dependent variables of mental health among the participants that affect the music performers. The unstandardized coefficients indicate that for each one-unit increase in stress levels, mental health scores decrease by 0.45 units, suggesting a negative correlation between stress and mental health. Similarly, anxiety levels show a significant negative impact with a coefficient of −0.60, emphasizing the detrimental effect of anxiety on mental well-being. Conversely, muscle activity and hand movements are positively correlated with mental health, with a coefficient of 0.30 and 0.25, respectively, indicating that increased physical engagement can enhance mental health outcomes. The significance of the p values (all <0.05) confirms that these relationships are statistically significant, reinforcing the importance of addressing psychological stressors and promoting physical activity to support the mental health of pianists. Overall, the multiple regression analysis highlights key factors that can inform interventions aimed at improving the psychological well-being of musicians.

4.3.2. Results obtained by using descriptive analyses

Initially, descriptive analyses were performed in the study to calculate the effectiveness of participants before and after the intervention of the experiment. **Table 4** displays the test findings for the descriptive analysis method's within-group comparisons.

Table 4. Descriptive analysis.

Metric	Mean	Standard deviation	Minimum	Maximum	N
Stress	3.50	0.85	1	5	150
Anxiety	3.20	0.90	1	5	150
Muscle activity	4.00	0.75	2	5	150
Hand moments	3.80	0.70	2	5	150
Mental health	2.90	1.00	1	5	150

The descriptive analysis results provide a comprehensive overview of the metrics related to 5 participants. The mean scores indicate the average levels for each metric, with stress averaging at 3.50, suggesting a moderate level of stress experienced by the pianists. Anxiety levels, with a mean of 3.20, further highlight the presence of psychological tension within the population. The standard deviation values reveal variability in the responses, with stress levels showing a standard deviation of 0.85, indicating reasonable degrees of dispersion around the mean. Each metric's minimum and maximum values span from 1 to 5, representing the whole range of participant experiences from low to high levels of stress and anxiety. Overall, the descriptive statistic laid the groundwork for understanding the participant's psychological and physical conditions, which can inform subsequent analyses and interventions.

4.4. Proposed method evaluation

The category explains the results produced by implementing the approach using the DFS-RSVM method, as shown in **Table 5**.

- Classical music: The genre encompasses a broad range of music composed from the late Middle Ages, characterized by its sophisticated structure and complexity. Classical music is typically written for orchestras' chamber ensembles or solo instruments and includes various forms such as symphonies, concertos and operas.
- Pop music: It is a modern genre renowned for its universal appeal, catchy melodies, and repeating structures. It frequently incorporates elements of other musical styles, including rock, hip-hop, and electronic dance music. Pop songs typically feature simple lyrics that focus on themes of love, relationships, and everyday life.
- Melody: It speaks of a series of sounds that are interpreted as one cohesive whole. It serves as the primary theme or song and is frequently regarded as the most identifiable and memorable element of a work of music. Melodies' are typically characterized by their pitch, rhythm and contour and they can evoke various emotions depending on their structure and performance. Melodies can be simple, with a few notes repeated, or complex, featuring intricate patterns and variations. In various musical styles, melodies play a vital part in expressing the composition's overall tone and meaning.

Table 5. Performance quality score.

Classification region	**Performance quality score**		
	Beginner	**Intermediate**	**Advanced**
Positive hyperplane	60	75	90
Zero plane	65	80	85
Negative hyperplane	55	70	95

The beginning performance quality score demonstrates the fundamental abilities of inexperienced pianists who are just beginning to learn tunes. Although RSVM novices can play straightforward piano, a positive hyperplane recognized the positive emotions of the piano players, achieved by 55–60suggests that they frequently have difficulty with expressiveness and rhythm. A zero plane recognized the zero emotions of the piano players achieved by 65 in pop music indicates that newcomers can grasp simple tunes and chords but could not have the confidence to execute them flawlessly. Classical pieces are more challenging because they have a negative hyperplane recognized the negative emotions of the piano players, achieved below 55, which emphasizes the difficulty of learning complex finger techniques and expressive dynamics. This makes classical music especially intimidating for beginners, as shown in **Figure 5**.

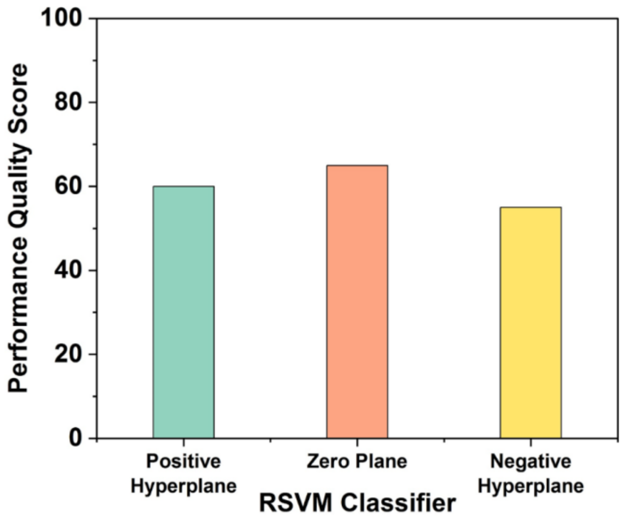

Figure 5. Outcomes of beginner.

Intermediate performers receive an average performance score due to their noticeable skill improvement. With a positive hyperplane recognized the positive emotions of the piano players, achieved by 75, it appears that these pianists are capable of playing more difficult songs with greater emotion and fluidity. The emotions-controlled players are recognized in the zero plane of the piano players achieved with a score of 80 are able to enhance their performance by adding variations and embellishments. Even while intermediate pianists are more technically proficient and are able to perform more difficult compositions, A negative hyperplane recognized the negative emotions of the piano players achieved by70 indicates that they may still find it difficult to portray the depth and subtleties of feeling that advanced players are able to. As seen in **Figure 6**, DFS-RSVM evaluates their psychological well-being in addition and offers insights into how these affective aspects affect performance quality.

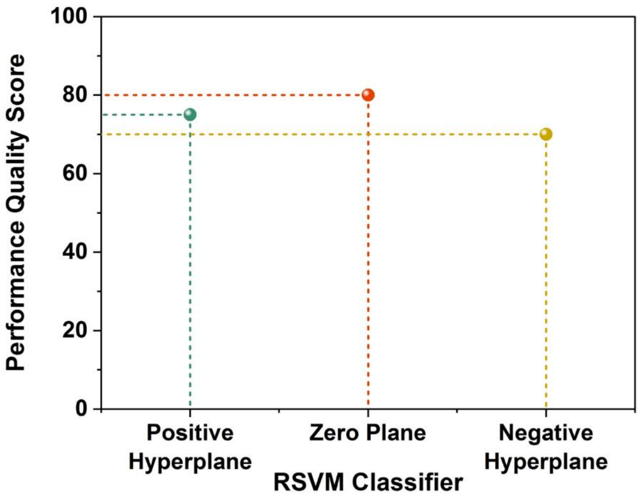

Figure 6. Outcomes of intermediate.

Professional pianists can perform at a high, medium, or low level depending on how well they grasp their methods and how well they can handle mental and physical strain. A positive hyperplane recognized the positive emotions of the piano players achieved by 90 denotes exceptional mental attention and control over biomechanical pressures, as well as technical perfection and emotional depth. In pop, for example, a zero hyperplane recognized the zero emotions of the piano players achieved by80–89indicate originality and personal flair; yet, moderate stress levels may compromise consistency. A negative hyperplane recognized the negative emotions of the piano players achieved by below than 80indicate difficulties sustaining mental health, which results in decreased technical correctness. Based on DFS-RSVM analysis, these performance levels demonstrate the critical relationship between psychological well-being and musical performance. as shown in **Figure 7**.

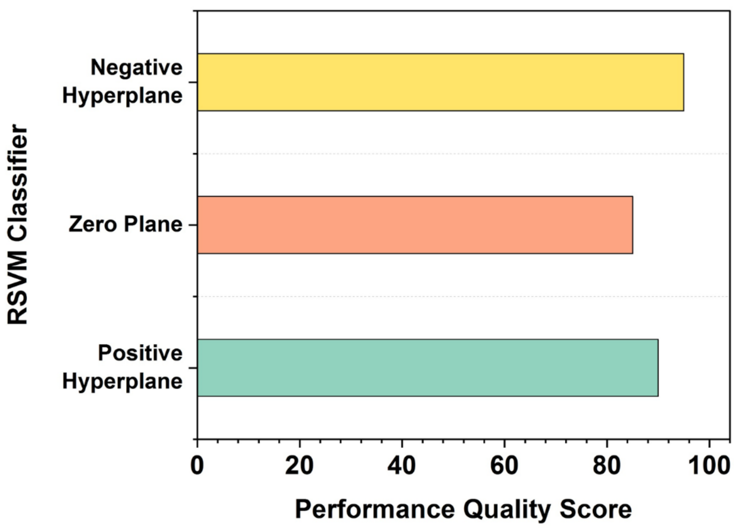

Figure 7. Outcomes of advanced.

5. Conclusion

Exploring the complex relationship between piano playing and music performance was the goal of the study. Status and their psychological health, focusing on innovative data mining techniques and biomechanics and by employing the novel DFS-RSVM, the research assessed key psychological health factors, such as stress and anxiety, in relation to piano performance. The collected biomechanical data encompassing posture, hand movements, muscle activity and finger force was meticulously preprocessed using normalization and analyzed through discrete wavelet transforms. The results demonstrated significant connections between biomechanical stressors and psychological health, highlighting the necessity for preventive strategies in mental health support. The study highlights several advantages for piano players, including enhanced awareness of the interplay between their psychological health and performance quality. By utilizing biomechanical data and advanced data mining techniques, pianists can identify stressors, improve technique, and ultimately achieve better emotional expression and technical proficiency in their performances. Although the study offers insightful information, its relatively small sample size and concentration on a particular subset of piano artists limit how broadly the results can be applied. Additionally, the study primarily concentrated on psychological health factors, leaving other relevant dimensions, such as social support and environmental influences, less explored. Future research could expand the sample size and include diverse musical genres and performance contexts. Furthermore, integrating longitudinal data collection could provide deeper insights into the long-term effects of psychological health on performance and the efficacy of various intervention strategies.

Ethical approval: Not applicable.

Conflict of interest: The author declares no conflict of interest.

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