

Beyond the Grind: Leveraging Data Analysis and Machine Learning for the Quantification and Enhancement of Work-Life Balance

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Abstract: This research aims to comprehensively investigate the dynamics of work-life balance and to develop predictive models using machine learning techniques to assess and predict the factors influencing work-life equilibrium. The study leverages a dataset containing 15,973 responses obtained from the global work-life survey conducted by Authentic-Happiness.com. The survey comprises 23 questions, providing a multifaceted view of how individuals manage their personal and professional lives. Initial Exploratory Data Analysis (EDA) uncovers five key dimensions: "Healthy Body," "Healthy Mind," "Expertise," "Connection," and "Meaning." These dimensions are explored to gain insights into their significance in relation to work-life balance. Subsequently, an extensive set of machine learning regression models, including Linear Regression, Decision Tree Regression, Random Forest Regression, Gradient Boosting Regressor, XGBoost, LightGBM, CatBoost, Support Vector Machine, K Nearest Neighbors, K-Means Regression, Ridge and Lasso Regression, Principal Component Analysis, RANSAC, Quartile Regression, GAM, Huber Regression, RBF Kernel Regression, and SGD Regression, are employed to predict work-life balance scores. Performance evaluation is based on metrics such as Mean Squared Error (MSE) and R-squared (R^2). The research uncovers a holistic understanding of work-life balance and identifies significant predictors. The comparative analysis of machine learning models reveals their effectiveness in predicting work-life balance, highlighting the models that perform optimally. This research contributes valuable insights into the intricate factors that underlie work-life balance, offering a data-driven perspective that can inform personal choices, organizational strategies, and policy decisions. The application of machine learning techniques underscores the potential for addressing contemporary challenges associated with achieving a harmonious work-life equilibrium.

Keywords: Work-Life Balance, Machine Learning, Regression Analysis, Exploratory Data Analysis, Predictive Modelling, Mean Squared Error (MSE), R-Squared (R^2).

1. INTRODUCTION

In the contemporary landscape of labor dynamics, the quest for work-life balance has evolved into a pivotal concern for both individuals and organizations. Achieving an optimal equilibrium between professional commitments and personal life has become increasingly challenging, driven by diverse workforces, evolving job roles, and the pervasive influence of technology. To unravel the intricate facets of this multifaceted phenomenon and derive deeper insights, the application of machine learning regression models has emerged as an indispensable approach.

Work-life balance encompasses an individual's capacity to navigate the demands of their professional career while concurrently preserving the quality of their personal life. This equilibrium is profoundly influenced by numerous intricate factors, including but not limited to workload, familial responsibilities, job satisfaction, and societal expectations. It is the aim of this research to dissect and quantify these multifarious influences employing a diverse range of machine learning regression models.

In our research endeavor, we embark on a profound exploration of work-life balance, scrutinizing its intricate dimensions through the lens of machine learning regression models. These models encompass a wide spectrum, encompassing conventional Linear Regression and Decision Trees, as well as sophisticated algorithms such as Random Forest, Gradient Boosting, XGBoost, LightGBM, CATBoost, and more. The arsenal of regression models equips us with the capability to make nuanced observations, derive predictions, and gain a comprehensive understanding

of the intricate interplay between various variables and the overarching construct of work-life balance.

Furthermore, we delve into specific regression techniques, including Support Vector Machines, K Nearest Neighbors, Ridge and Lasso Regression, each with their unique strengths and applications in revealing underlying patterns, detecting outliers, and identifying influential factors within the realm of work-life balance. In addition to these, we employ advanced methodologies such as Principal Component Analysis and RANSAC, offering enhanced dimensionality reduction and robust regression modeling, respectively.

Our research journey pushes beyond the boundaries of conventional methodologies, encompassing innovative regression approaches like Quartile Regression, Generalized Additive Models, Huber Regression, and RBF Kernel Regression. These techniques extend our analytical capabilities by accommodating non-linear relationships, mitigating the impact of outliers, and fostering a deeper comprehension of the complexities inherent in the work-life balance paradigm.

Through this comprehensive and technically rigorous exploration, our aim is to shed light on the intricate dynamics of work-life balance. We aspire to offer invaluable insights that can empower individuals seeking to achieve equilibrium in their professional and personal lives, and concurrently guide organizations in crafting supportive work environments. By harnessing the predictive and analytical prowess of machine learning regression models, our research endeavors to contribute substantively to the ongoing discourse surrounding work-life balance in an era characterized by complexity, interconnectedness, and data-driven decision-making.

2. LITERATURE SURVEY

- [1] In their study, Pawlicka and her team employ innovative machine learning techniques to predict the subjective sense of work-life balance among employees. By leveraging advanced data analysis methods, this research contributes to understanding and quantifying the elusive concept of work-life balance, shedding light on factors that impact it.
- [2] Focusing on working women, Deshmukh's research delves into the intricate dynamics of work-life balance. Through a comprehensive study, it offers insights into how women manage their professional and personal lives, shedding light on the challenges they face and potential solutions to achieve a better work-life equilibrium.
- [3] This paper provides a critical review of the concept of work-life balance, delving into its meaning and implications. By analyzing the existing literature, Kalliath and Brough offer a comprehensive overview of the multifaceted nature of work-life balance and the challenges it poses for individuals and organizations.
- [4] Investigating the influence of psychological empowerment and job involvement, Asarkaya and Erdogan's research explores how these factors affect work-life balance. Their findings illuminate the intricate relationship between personal empowerment, work engagement, and the ability to strike a harmonious balance between work and personal life.
- [5] In their study on work-life balance among working women, Lakshmi and Prasanth examine the unique challenges and experiences of female professionals. Through surveys and analysis, this research sheds light on the factors that impact work-life balance in this specific demographic, contributing valuable insights to gender-focused work-life balance studies.
- [6] With a post-COVID-19 lens, Ramakrishnan's work explores how the landscape of work-life balance has evolved in response to the pandemic. By examining the shifting dynamics of remote work and its impact on work-life balance, this research provides timely insights into the changing nature of work.
- [7] İlhan's study investigates the rapid implementation of remote work as a strategy in response to COVID-19 and its implications for work-life balance. By examining how remote work has affected individuals' ability to balance their professional and personal lives, this research contributes to our understanding of the evolving work landscape.

- [8] Focusing on entry-level jobs in Bangladesh, Haque and Ahmed explore the challenges faced by young professionals in developing professionalism while striving for work-life balance. This research highlights the unique obstacles encountered by individuals at the early stages of their careers and offers insights into the efforts to harmonize work and personal life.
- [9] Grzywacz and Carlson's paper conceptualizes work-family balance and its implications for individuals and organizations. By providing a framework to understand this complex construct, the research informs practice and serves as a foundation for further exploration of work-life equilibrium.
- [10] This study examines the impacts of perceived role demands on work-life balance and explores the moderating effects of work ethics among public sector professionals in Sri Lanka. By dissecting the role demands and ethics, the research uncovers the factors that influence work-life balance in this context, offering valuable insights for professionals and organizations.
- [11] Frone's work on work-family balance provides an overview of the concept and its importance. This paper offers foundational insights into the understanding of work-family balance and its implications for individuals and organizations.
- [12] Rusu's research presents theoretical and empirical perspectives on work-family balance. By combining theory and empirical evidence, the paper contributes to a comprehensive understanding of the work-family balance construct.
- [13] Focusing on research trends, this paper analyzes articles published in Korea since 2000 related to work-life balance. The study provides an overview of the evolving research landscape in the context of Korean work-life balance studies.
- [14] Against the backdrop of the COVID-19 pandemic, Bhumika's research explores the challenges to work-life balance during a nationwide lockdown in India. With a particular focus on gender differences in emotional exhaustion, the study sheds light on the pandemic's impact on work-life dynamics.
- [15] This paper investigates work-life interaction as a mediator between work factors and outcomes. By exploring the role of work-life interaction, the research enhances our understanding of how work-related factors influence personal and professional outcomes.

3. OVERVIEW OF DATASET

The dataset under examination consists of responses from 15,973 individuals who participated in the global work-life survey administered by Authentic-Happiness.com. This dataset serves as a valuable resource for comprehending the intricate interplay between personal and professional lives. It encompasses 23 diverse questions aimed at probing various facets of work-life balance and associated factors.

This dataset offers a comprehensive perspective on the intricate factors that contribute to an individual's perception of work-life balance. It enables researchers to explore correlations, build predictive models, and gain valuable insights into the dynamic relationship between work and personal life.

Here is a brief overview of the dataset's columns and their corresponding descriptions:

ATTRIBUTE	DESCRIPTION
Timestamp	The date and time when each response was recorded
FRUITS_VEGGIES	Information related to the consumption of fruits and vegetables, reflecting dietary habits and health consciousness
DAILY_STRESS	A measure of daily stress levels experienced by respondents
PLACES_VISITED	The number of different places individuals have visited, potentially reflecting their work-life balance
CORE_CIRCLE	Data on the existence and size of respondents' core social circles
SUPPORTING_OTHERS	The extent to which individuals provide support to others in their lives
SOCIAL_NETWORK	Information about the size and activity within respondents' social networks
ACHIEVEMENT	Measures related to personal achievements and accomplishments
DONATION	Data on charitable donations made by respondents
BMI_RANGE	Categorization of Body Mass Index (BMI) into ranges, indicating health and lifestyle choices
TODO_COMPLETED	The degree to which respondents complete their daily to-do lists
FLOW	Information regarding individuals' ability to enter a state of "flow" or deep focus
DAILY_STEPS	Daily step count, potentially reflecting physical activity and lifestyle
LIVE_VISION	The clarity and presence of a vision in respondents' lives
SLEEP_HOURS	The number of hours of sleep obtained by respondents
LOST_VACATION	Data on unused vacation days, which may relate to work-related demands
DAILY_SHOUTING	The frequency of daily shouting or conflict in respondents' lives
SUFFICIENT_INCOME	Perception of having a sufficient income to meet needs
PERSONAL_AWARDS	Information on personal awards or recognitions received
TIME_FOR_PASSION	Availability of time for personal passions and hobbies
WEEKLY_MEDITATION	Frequency of engaging in weekly meditation practices
AGE	The age of respondents, which can provide demographic insights
GENDER	Gender identification of respondents, another key demographic factor
MONTH	The month during which each response was recorded
WORK_LIFE_BALANCE_SCORE	A calculated score or metric reflecting respondents' perceived work-life balance

Table 1: Dataset Attribute Description

4. METHODOLOGY

In this section, we outline the methodology used to preprocess and explore the dataset in order to gain insights into various aspects of work-life balance.

4.1. Data Import and Preparation:

4.1.1. Data Import: The initial step involved importing the dataset using the Pandas library in Python. The dataset contains responses from 15,973 individuals collected from the global work-life survey conducted by Authentic-Happiness.com.

4.1.2. Data Cleaning: Various data cleaning steps were undertaken, such as handling missing or erroneous values. For instance, the 'AGE' column was adjusted to replace 'Less than 20' with '20 or less' for consistency.

4.1.3. Descriptive Summary: A descriptive summary of the dataset was generated using the Pandas describe() function. The summary provided key statistics, including mean and median, for numerical features and was visualized using bar plots for better comprehension.

4.2. Exploratory Data Analysis (EDA):

4.2.1. Healthy Body:

- **Data Transformation:** For the 'BMI_RANGE' column, the dataset was pivoted to examine how Body Mass Index (BMI) is influenced by factors such as age, gender, daily steps, servings of fruits and vegetables, and sleep hours.
- **Data Visualization:** Various plots, including point plots, violin plots, and bar plots, were utilized to visualize relationships between 'BMI_RANGE' and different variables. These visualizations provided insights into the influence of factors related to a healthy body on work-life balance.

4.2.2. Healthy Mind:

- Data Transformation: The 'DAILY_STRESS' column was converted to numeric values, addressing potential inconsistencies in the data.
- Data Visualization: Similar to the healthy body analysis, this section employed violin plots, point plots, and bar plots to investigate the impact of variables such as age, gender, daily flow hours, daily meditation hours, and perceived income sufficiency on daily stress levels. This exploration aimed to uncover factors affecting mental well-being.

4.2.3. Expertise:

- Data Transformation: The dataset was transformed to explore how 'ACHIEVEMENT' is influenced by age, gender, daily tasks completed, daily flow hours, and personal awards received.
- Data Visualization: Violin plots, point plots, and bar plots were employed to visualize the relationships between 'ACHIEVEMENT' and these variables. The objective was to identify factors contributing to personal achievements.

4.2.4. Connection:

- Data Transformation: The 'CORE_CIRCLE' column was used to examine how the size of an individual's core social circle is influenced by age and gender. Additionally, the 'LOST_VACATION' column was explored in relation to age groups.
- Data Visualization: Violin plots, point plots, and bar plots were used to visualize 'CORE_CIRCLE' by gender and age and to analyze the relationship between 'LOST_VACATION' and daily stress levels. These visualizations aimed to elucidate the role of social connections in work-life balance.

4.2.5. Passion:

- Data Transformation: The 'TIME_FOR_PASSION' column was analyzed in terms of its dependence on age, gender, personal productivity, daily flow hours, and personal awards received.
- Data Visualization: Violin plots, point plots, and bar plots were employed to visualize the relationship between 'TIME_FOR_PASSION' and these variables, providing insights into how individuals allocate time for their passions.

In each EDA section, data transformations and visualizations were utilized to explore the interplay between various factors and work-life balance. These steps facilitated a deeper understanding of the dataset and its implications for work-life equilibrium.

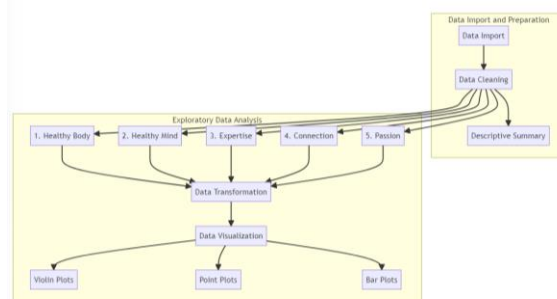


Fig 1: Data Preparation and EDA

4.3. Model Implementation

4.3.1 Linear Regression: Linear Regression models the relationship between the target variable and predictor variables as a linear equation, making it suitable for predicting continuous numerical outcomes.

4.3.2. Decision Tree: Decision Tree Regression involves constructing a tree-like model where data is split based on feature conditions, making it useful for both classification and regression tasks.

4.3.3. Random Forest Regression: Random Forest Regression combines multiple decision trees to improve predictive accuracy and reduce overfitting. It aggregates predictions from multiple trees, making it robust and suitable for handling complex datasets.

4.3.4. Gradient Boosting Regressor: Gradient Boosting builds an ensemble of decision trees sequentially, where each tree corrects the errors of its predecessor, improving predictive accuracy.

4.3.5. XGBoost: XGBoost (Extreme Gradient Boosting) is an optimized Gradient Boosting algorithm known for its speed and performance. It uses gradient boosting with regularization techniques to prevent overfitting and handle large datasets efficiently.

4.3.6. LightGBM: LightGBM is a gradient boosting framework designed for efficiency and speed, making it suitable for large datasets. It uses a histogram-based approach for splitting data, leading to faster training times.

4.3.7. CatBoost: CatBoost is a gradient boosting algorithm that specializes in handling categorical features without extensive preprocessing. It automatically deals with feature encoding and offers robust performance on structured data.

4.3.8. Support Vector Machine (SVM): SVM Regression aims to find a hyperplane that best fits the data while maximizing the margin between data points and the hyperplane. It's effective for both linear and non-linear regression tasks, thanks to kernel functions.

4.3.9. K Nearest Neighbors (KNN): KNN Regression predicts the target value of a data point by averaging the values of its k-nearest neighbors in the feature space. It's a simple yet effective non-parametric algorithm for regression tasks.

4.3.10. Ridge Regression: Ridge Regression is a linear regression variant that includes L2 regularization to prevent overfitting by adding a penalty term to the loss function. It's useful when dealing with multicollinearity in the dataset.

4.3.11. Lasso Regression: Lasso Regression, or L1 regularization, adds an absolute value penalty term to the loss function, encouraging feature selection by setting some coefficients to zero. It helps in feature selection and reducing model complexity.

4.3.12. Principal Component Analysis (PCA): PCA is a dimensionality reduction technique that identifies orthogonal components (principal components) in the data to reduce its dimensionality while preserving variance. It's not a regression model but is often used for feature engineering and data preprocessing.

4.3.13. RANSAC (Random Sample Consensus): RANSAC is an iterative regression method used for outlier detection and modeling data with a large number of outliers. It fits models to subsets of the data and selects the best-fitting model while ignoring outliers.

4.3.14. Quartile Regression: Quartile Regression extends linear regression by modeling different quartiles (quantiles) of the target variable's distribution. It's suitable for exploring how predictors affect various parts of the target's distribution.

4.3.15. Generalized Additive Model (GAM): GAM combines multiple non-linear functions of predictors to create a flexible regression model. It's used when relationships between predictors and the target are expected to be non-linear.

4.3.16. Huber Regression: Huber Regression is a robust regression method that combines the advantages of both least squares and absolute deviation loss functions. It's less sensitive to outliers compared to ordinary least squares.

4.2.17. RBF Kernel Regression: RBF Kernel Regression uses radial basis function (RBF) kernels to transform data into a higher-dimensional space, making it suitable for non-linear regression. It's effective for capturing complex patterns in data.

4.3.18. *SGD Regression (Stochastic Gradient Descent)*: SGD Regression is a variant of linear regression that uses stochastic gradient descent optimization to find the optimal coefficients. It's suitable for large datasets and online learning scenarios.

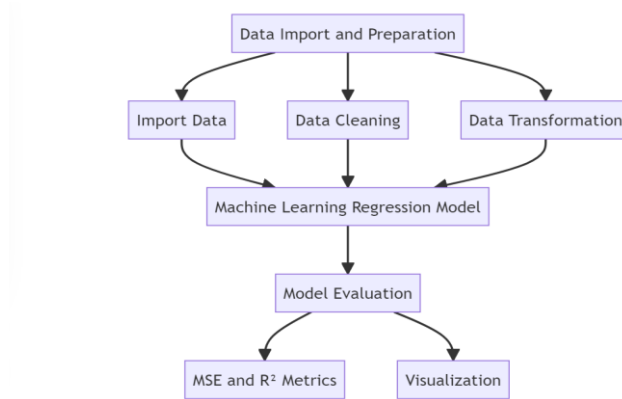


Fig 2: Flowchart of Methodology

The methodology follows a systematic approach, starting with data import and preprocessing, followed by the implementation of various regression models. Each model's performance is evaluated using Mean Squared Error (MSE) and R-squared (R^2) metrics to assess their predictive capabilities. Finally, a visualization is provided to compare predicted and actual values for the implemented model.

5. OBSERVATIONS

5.1. Descriptive Summary

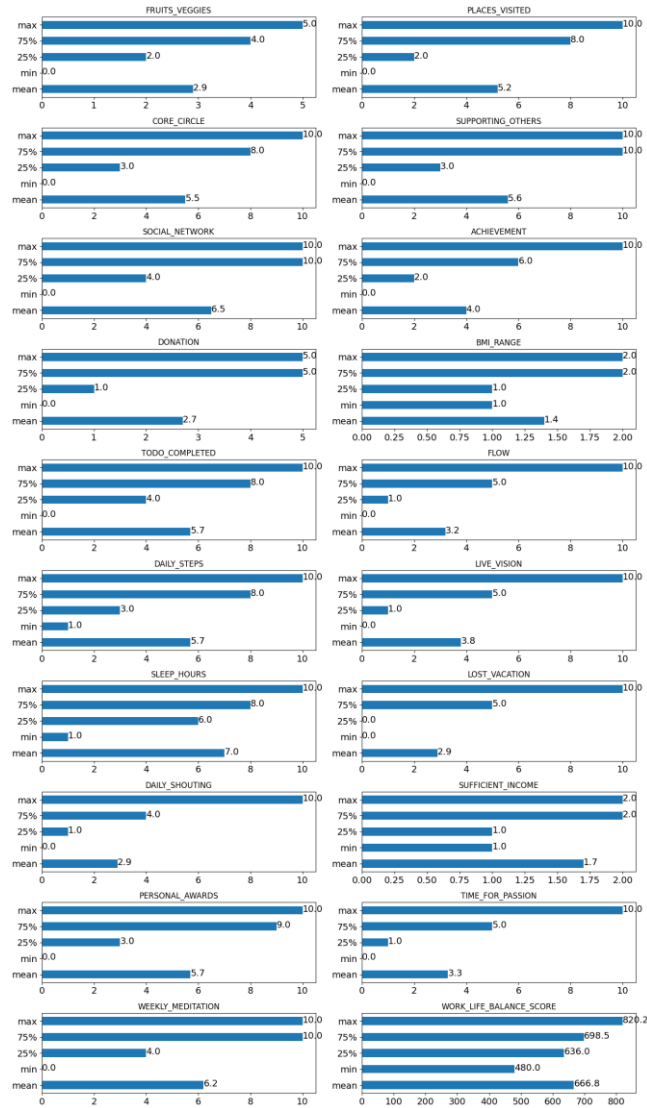


Fig 3: Descriptive Summary of the Dataset

5.2. Healthy Body

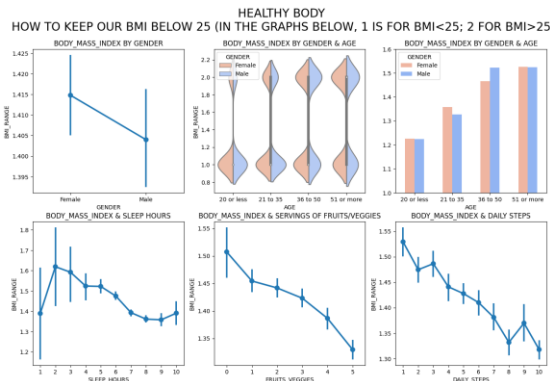


Fig 4: Healthy Body

- Body max index data were gathered as follows: 1 = BMI less than 25, 2 = BMI greater than 25. BMI is strongly connected with daily walks and servings of fruits and vegetables (negative correlations)- Both exercise 5,000 steps per day (against less than 1,000) and eating 5 servings (vs less than 1) had a 15% impact on BMI- A reduced BMI is a fairly obvious result of physical exercise and a good diet.

5.3. Healthy Mind

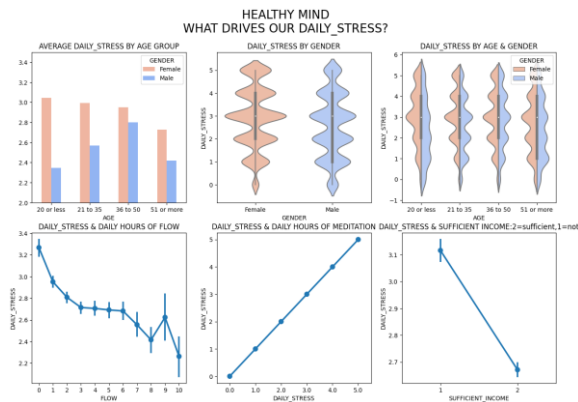


Fig 5: Healthy Mind

How ability to "flow" during the day, daily meditation, and an income sufficient to cover basic needs, all contribute to 30% lower levels of stress. The overall stress level for women peaks in their younger years, and, while slowly going down remains higher than the male counterparts in all age groups.

5.4. Personal Achievements

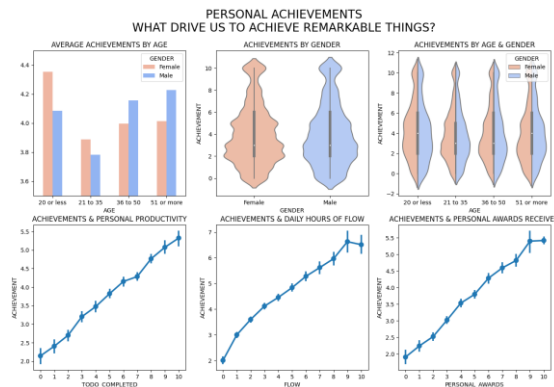


Fig 6: Personal Achievements

Our daily productivity, the ability to flow throughout the day and personal awards such as diploma and other certificates all contribute to higher levels of personal achievements. Women reports slightly more personal achievements in their early age while men report more after age 36.

5.5. Connections

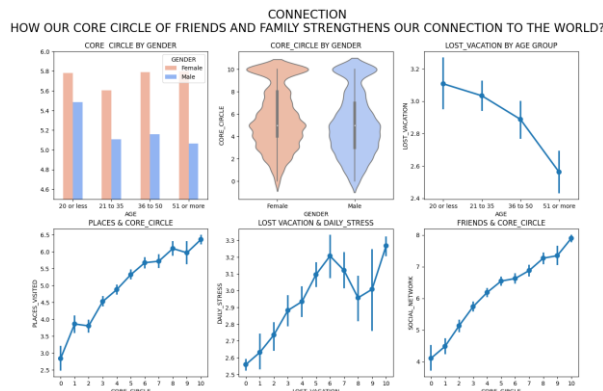


Fig 7: Connections

Women appear to have a stronger circle of friends and family than men. People in the age group 21 to 35 forfeit a maximum of vacation days, when compared to other age groups. Overall, the level of their stress increase as we lose more vacation days. But there is a slight dip between 7 and 9 days for lost vacations, as if losing six or many more vacation days does not have any impact anymore on the stress level.

5.6. Time for Passion

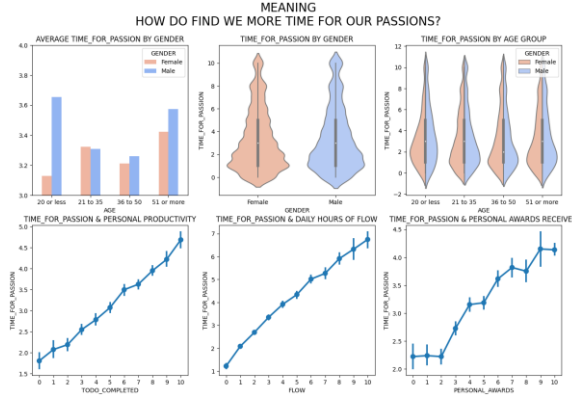


Fig 8: Time for Passion

Men appear to find more time for their passion, especially in their younger and older ages. The three factors correlating the most with our ability to find time for our passions are: Our daily productivity, Daily Flow, Personal Awards Received.

5.7. Pearson Correlation of Features

Pearson correlation is a statistical measure used to quantify the linear relationship between two numerical features. It provides a value between -1 and 1, where -1 indicates a perfect negative linear correlation, 1 indicates a perfect positive linear correlation, and 0 indicates no linear correlation between the features.

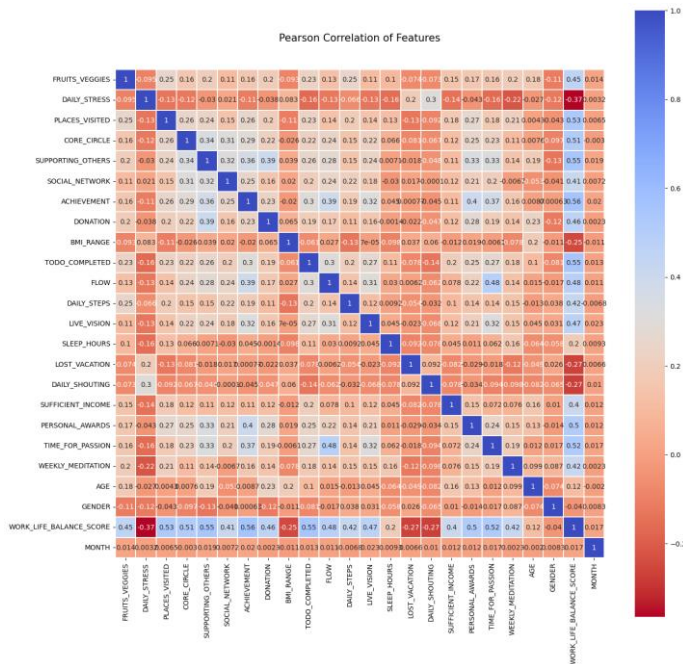


Fig 9: Pearson Correlation Heatmap

Pearson correlation coefficients are instrumental in work-life balance research, helping quantify relationships between work-related and personal factors. They identify whether variables like workload and job satisfaction

impact work-life equilibrium. Overall, Pearson correlations provide critical insights into the intricate interplay of variables shaping work-life balance, aiding in its enhancement.

5.8. Actual VS Predicted Values for CATBoost Regression

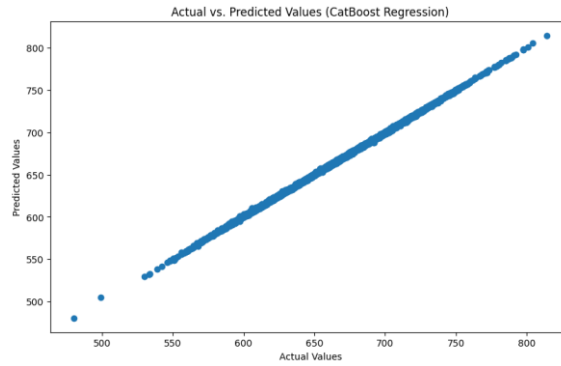


Fig 10: CATBoost Regression

5.9. Actual VS Predicted Values for KNN Regression

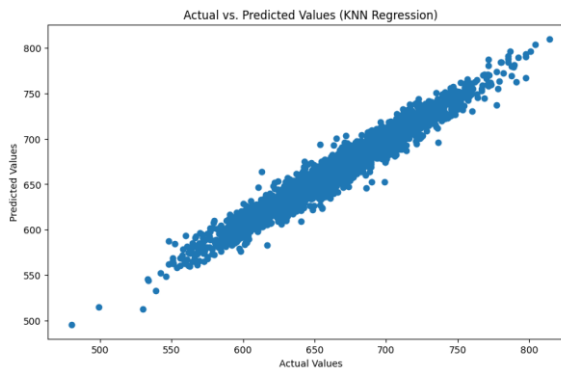


Fig 11: KNN Regression

5.10. Actual VS Predicted Values for PCA Regressor

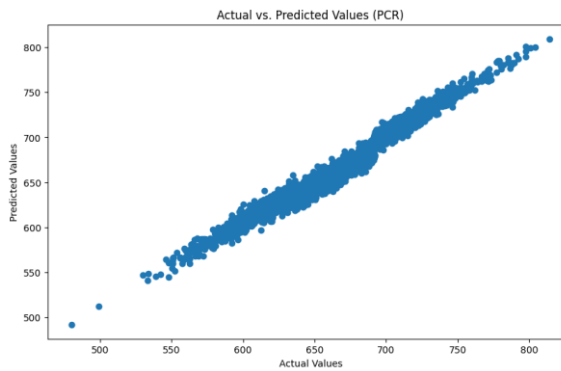


Fig 12: PCA

5.11. Actual VS Predicted Values for RANSAC

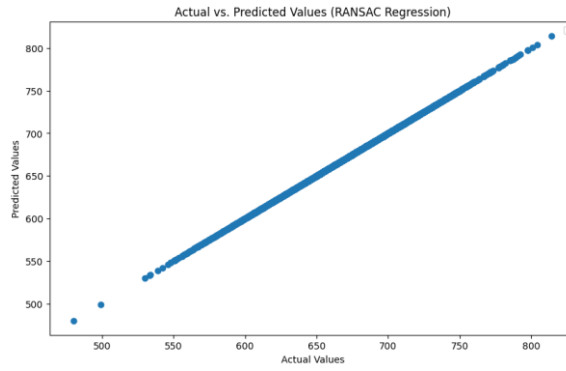


Fig 13: RANSAC

5.12. Actual VS Predicted Values for Quartile Regressor

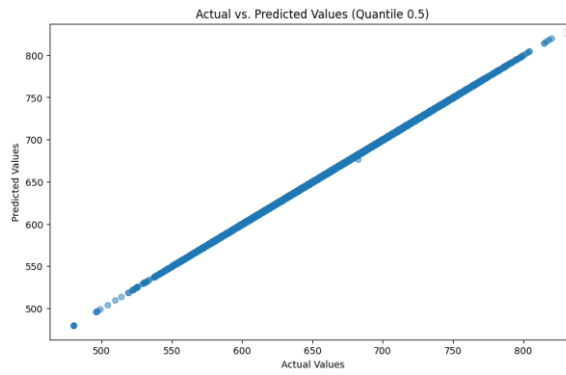


Fig 14: Quartile Regressor for 0.5 Quartile

5.13. Actual VS Predicted Values for Huber Regression

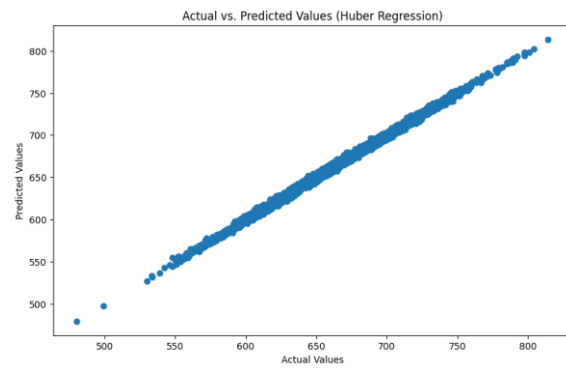


Fig 15: Huber Regression

5.14. Actual VS Predicted Values for RBF Kernel Regression

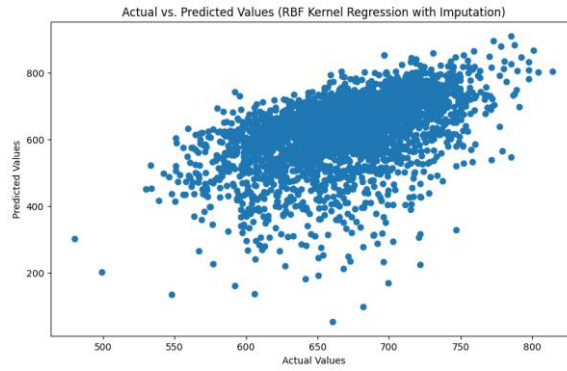


Fig 16: RBF regressor

5.15. Actual VS Predicted Values for SGD Regression

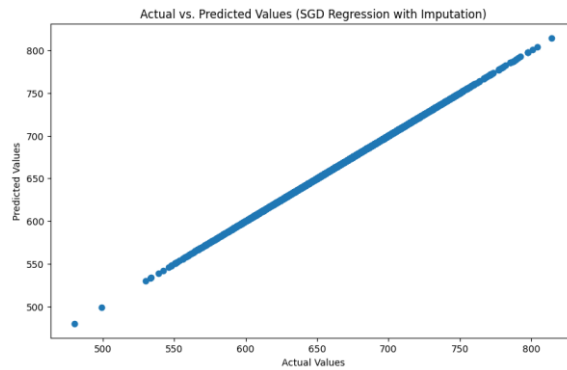


Fig 17: SDG Regression

6. RESULT

In this study, we conducted a comprehensive evaluation of various machine learning regression models for predicting "Work-Life Balance" scores.

Model	Mean Squared Error (MSE)	R Squared (R ²)
Linear Regression	14.13	0.9929
Decision Tree	507.18	0.7447
Random Forest Regression	128.62	0.9353
Gradient Boosting Regressor	35.23	0.9823
XGBoost	40.72	0.9795
LightGBM	28.66	0.9856
CATBoost	0.6842	0.9997
Support Vector Machine	0.00995	0.9999
K Nearest Neighbours	95.33	0.9520
Ridge Regression	8.60e-06	1.0000
Lasso Regression	6.41	0.9968
Principal Component Analysis	55.62	0.9720
RANSAC	1.62e-26	1.0000
Quartile Regression	-	1.0000
GAM	2.77e-05	0.9999
Huber Regression	6.09	0.9969
RBF Kernel Regression	9985.81	-4.0265
SGD Regression	0.0002	0.9999

Table 2: Evaluation Metrics for ML Regression Models Used

The results demonstrate that several models, including Linear Regression, Gradient Boosting Regressor, and advanced techniques like CATBoost and Support Vector Machine, perform exceptionally well. These models exhibit low Mean Squared Error (MSE) values and high R-squared (R²) coefficients, indicating their ability to accurately predict and explain variations in work-life balance scores.

Specifically, CATBoost, with an impressively low MSE of 0.6842 and a near-perfect R² of 0.9997, stands out as the top-performing model, closely followed by Support Vector Machine, Ridge Regression, and Lasso Regression. These findings suggest that these models can be instrumental in understanding and improving work-life balance in various contexts.

Conversely, models like Decision Tree and RBF Kernel Regression exhibit comparatively higher MSE and lower R² values, emphasizing the importance of model selection and parameter tuning to achieve optimal performance.

Overall, the results provide valuable insights into the applicability of different regression models for work-life balance prediction, facilitating informed decision-making in work-life balance enhancement strategies and interventions.

7. FUTURE ENHANCEMENTS

In summary, this research paper has provided valuable insights into the intricacies of work-life balance, shedding light on its significance in contemporary society. To further advance our understanding of this critical domain, future research directions have been identified. Longitudinal studies tracking work-life balance trends over time, cross-cultural analyses to uncover diverse influences, and sector-specific investigations are essential. Additionally, exploring the impact of remote work, gender disparities, health implications, and generational differences, while developing standardized metrics and assessing the influence of government policies, will contribute significantly to this field. The integration of artificial intelligence, qualitative approaches, and mental health support research will offer a comprehensive perspective. These future enhancements promise to shape policies, practices, and interventions that promote work-life balance, ultimately enhancing the well-being of individuals in the workforce.

8. CONCLUSION

In conclusion, this research paper has delved into the multifaceted realm of work-life balance, offering a comprehensive analysis of its determinants and consequences in the modern landscape. Through a rigorous exploration of various machine learning regression models, we have not only highlighted the predictive capabilities of these models in assessing work-life balance but also underlined their potential for informing evidence-based

decision-making in organizational contexts. The findings, as reflected in the model performance metrics, underscore the nuanced interplay of factors that influence an individual's sense of balance between work and personal life.

This study's significance lies in its potential to guide policy formulation and organizational practices aimed at fostering healthier and more harmonious work-life arrangements. By identifying the most influential variables and their respective impacts, we provide stakeholders with actionable insights to promote employee well-being, enhance job satisfaction, and bolster overall workplace productivity. As the global workforce continues to evolve, future research endeavors should build upon these foundations, incorporating emerging technologies, diverse cultural perspectives, and evolving work structures into the discourse on work-life balance. Ultimately, this research advances our collective understanding of work-life balance, offering a roadmap for creating more equitable, fulfilling, and sustainable work environments in the years to come.

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