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Optimizing Job Rotation through Biorhythm Analysis and Artificial Neural Network (ANN) Methodology

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ABSTRACT

Job rotation is defined as workers rotating between tasks with different exposure levels and occupational demands. Implementing effective job rotation strategies poses challenges, especially in determining the optimal timing and sequencing of rotations to ensure that employees are suitably matched with job roles. Existing studies indicate that many expectations regarding job rotation have not been fully achieved, as the prediction and measurement of its impact on organizational and individual productivity have not been adequately researched. A critical factor influencing individual productivity is the fluctuation in employee performance, driven by the cyclical mental and physical characteristics of employees, known as biorhythms. Current job rotation models do not adequately address biorhythms, which are inherently difficult to predict. No methodologies have been proposed to model, analyze, or predict these fluctuations in the context of job rotation strategies. This research addresses this gap by developing an artificial neural network (ANN) algorithm capable of modeling complex biorhythmic patterns derived from employee performance data. The proposed model refines job rotation strategies by optimizing the alignment between worker capacities and workstation demands. The method is also applied to an industrial case study, demonstrating its applicability and potential to improve overall operational efficiency.

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1. Introduction

Workers are the core elements of any productive industry, and the way in which they are assigned to their tasks can directly affect a company's performance (Tharmmaphornphilas & Norman, 2007). One area that has garnered significant attention is job rotation, a practice involving the systematic movement of employees between different roles, tasks, or departments within the organization. This approach not only fosters skill development and knowledge sharing but also mitigates the risks associated with monotony and burnout (Soligon et al., 202۰). However, implementing an effective job rotation strategy is fraught with challenges, as it requires careful consideration of various factors, including employee preferences, organizational needs, and individual biorhythms (Yousefi et al., 2023).

Optimization, defined as the strategic allocation of resources to maximize profits while minimizing costs, is a paramount concern across all sectors. Contemporary organizations are fervently dedicated to curtailing excess expenditures and enhancing productivity (Kovacova & Lăzăroiu, 2021). Previous research has highlighted the potential benefits of job rotation, including increased job satisfaction, improved employee engagement, and enhanced organizational flexibility (Jasmine & Kania, 2022). Additionally, studies have explored the role of biorhythms—cyclical patterns that influence an individual's physical and mental states—in influencing employee performance, productivity, and overall well-being (Shahiri et al., 2023). Furthermore, the application of artificial neural networks (ANNs) in workforce management has shown promising results in predicting employee behavior and optimizing resource allocation (Alzeraif & Cheaitou, 2023).

The effectiveness of job rotation appears to depend on various factors, including employee performance levels, job demands, and implementation structure (Jasmine & Kania, 2022). many expectations towards job and task rotation are not fully supported, suggesting that the effectiveness of rotation may vary depending on the context and implementation (Mlekus & Maier, 2021). A critical factor influencing individual productivity is the fluctuation in employee performance, driven by the cyclical mental and physical characteristics of employees, known as biorhythms (Rastgar et al., 2020). Current job rotation models do not adequately address biorhythms which are inherently difficult to predict, as no methodologies have been proposed to model, analyze, or predict these fluctuations in the context of job rotation strategies. Existing studies indicate that many expectations regarding job rotation have not been fully achieved, as the prediction and measurement of its impact on organizational and individual productivity have not been adequately researched. These studies often remain static and do not account for fluctuations in employees' mental and physical characteristics, known as biorhythms. Such static plans do not consider the dynamic nature of employee capabilities or the varying demands of organizational productivity (Putz-Anderson, 2017). This limitation underscores the complexity of developing effective job rotation programs. The type of rotation implemented can significantly influence outcomes related to employee satisfaction and productivity (Alias et al., 2018). Moreover, organizational demands, including the physical and mental capacity of employees to perform assigned tasks, must be carefully considered. Failure to do so may result in poorly designed job rotation programs that negatively impact working conditions and overall employee morale (Putz-Anderson, 2017).

This research aims to address this gap by developing an artificial neural network (ANN) algorithm capable of modeling complex biorhythmic patterns derived from employee performance data. Recognizing and integrating these patterns can significantly enhance the alignment between job assignments and employees' optimal performance periods (Mehdizadeh et al., 2020). The proposed model refines job rotation strategies by optimizing the alignment between worker capacities and workstation demands.

In numerous previous studies, job rotation models have been designed primarily based on job-related factors and occupational risks. These studies have aimed to create models using the probabilities of occupational hazards to improve worker safety and health. For example, Padula et al. (2017) proposed job rotation programs to specifically reduce the incidence of musculoskeletal disorders among employees. These interventions have shown positive correlations with higher job satisfaction ratings, indicating that workers benefit from reduced physical strain and increased variety in their tasks (Padula, 2017). Additionally, Diego-Mas (2020) optimized a job rotation model to mitigate exposure to ergonomic risk factors, further validating the importance of incorporating physical health considerations into job rotation strategies.

Existing approaches often overlook the intricate interplay between individual biorhythms and job requirements. Consequently, organizations may struggle to maximize the benefits of job rotation while minimizing potential disruptions (Li, 2024). This gap highlights the need for a more dynamic and responsive model that can adapt to the fluctuating characteristics of employees, and there remains a gap in understanding how to effectively integrate biorhythm analysis and ANN methodologies into job rotation strategies. In this research, we develop an algorithm designed to extract and predict employees' biorhythm cycles and determine their optimal job rotation using a neural network methodology. The selection of a neural network algorithm is based on its ability to optimize the mathematical models of biorhythm cycles derived from newly collected data.

The integration of biorhythm analysis with ANN methodologies represents a significant advancement in job rotation models. By leveraging these advanced analytical techniques, this study provides a dynamic approach to job rotation that can adapt to the changing needs of both employees and organizations (Bautista & Cahigas, 2024).

This study introduces a groundbreaking framework that combines biorhythm analysis and ANN techniques to optimize job rotation strategies. This approach addresses the limitations of static job rotation plans by providing a dynamic, data-driven model that can adapt to fluctuating employee characteristics and organizational needs.

Using neural networks, this study analyzes data related to the physical and mental abilities of employees. Neural networks are well-suited for this task due to their ability to classify complex, nonlinear relationships in data, providing a more accurate and nuanced understanding of employee performance fluctuations. The mathematical model developed through this research offers a more precise and nonlinear cumulative optimization of job rotations. This model not only considers traditional job-related factors but also integrates data on employee characteristics, allowing for a more tailored and effective job rotation strategy.

2. Literature Review

2.1. Introduction to Job Rotation

Human resource optimization is a critical concern for organizations, especially in the dynamic landscape of modern large-scale enterprises. Strategic human resource management requires foresight and deliberate execution to drive organizational success (Geethanjali et al., 2024). The classification of jobs and employees within organizational frameworks is guided by two overarching theories, each emphasizing distinct approaches to job-role alignment and employee capabilities. The first theory focuses on adapting employees to predefined job roles, often seen in manufacturing settings, where job characteristics are standardized without considering individual talents. This approach may undervalue employee initiative and potential, leading to uniform compensation structures across roles. In contrast, the second theory advocates for aligning job assignments with individual capabilities, matching jobs with personnel based on unique abilities, commonly observed in governmental ministries (Sheikhalishahi et al., 2016). The concept of job rotation is grounded in several theoretical frameworks, including human capital theory, motivation theory, and organizational flexibility. Job rotation, as an investment in human capital, diversifies employees' skills and enhances their adaptability (Liang et al., 2023).

The effectiveness of personnel in fulfilling job responsibilities is not solely dependent on cognitive aptitude or technical skills but on the alignment of individual traits with job requirements. Understanding workplace traits is crucial for elucidating job performance determinants (Ayough et al., 2020). Proactive information monitoring and long-term planning are essential for successful human resource management, highlighting the importance of adept information processing for accurate forecasting and strategic planning (Rodgers et al., 2023).

The integration of advanced information processing technologies in human resource management has been met with mixed success. The automation of HR systems, evolving since the 1980s, promises efficiency but brings concerns about efficacy, implementation challenges, and potential errors (Wahdaniah et al., 2023; Ali et al., 2023).

2.2. Biorhythm Theory in the Workplace

In the context of organizational success, Gasparovich et al. (2021) emphasizes the criticality of employing appropriate processing models to identify, process, and plan personnel status effectively. The evolution from manual processing to advanced organizational systems has led to an escalation in the volume and complexity of human resource information. Moreover, Rastgar et al. (2020) researched how different dimensions of biorhythm could influence the ability of employees to cope with stress and recover from challenges in a work environment. This research aims to establish a connection between biorhythmic patterns and the overall resilience of employees, which is critical for maintaining productivity and mental well-being in the workplace. Sharma and Malodia (2022) highlight the essential role of Human Resources Information Systems (HRIS) and propose a person-to-job matching system to align employee competencies with job demands through the use of scoring matrices. Shahreki et al. (20١٩) note the evolving landscape of HR information processing, with technology becoming more accessible to smaller entities. Similarly, Botti et al. (2024) have introduced a bi-objective mathematical model aimed at assigning workers to various workstations to mitigate the risks associated with repetitive work. Their approach integrates analyses of workers' physical capacities, competencies, and mental skills with workstation requirements, facilitating a robust person-job fit paradigm. Their methodology employs integer planning techniques to minimize the number of working days lost due to injuries, thereby enhancing workplace safety.

2.3. Intersection of Biorhythm Analysis and ANN

Integrating biorhythm analysis and ANN methodology into job rotation strategies presents a novel approach that requires a deeper theoretical exploration and critical analysis (Li, 2024). Li (2024) examined how the combined application of performance appraisal and job rotation can enhance employee performance and contribute to overall organizational effectiveness. The study investigates the interrelationships between these two human resource management practices and their collective impact on enterprise renewal, which is essential for maintaining competitiveness in today’s rapidly changing business environment. Prior research has illuminated myriad qualitative factors influencing human resource productivity within organizations (Sheikhalishahi et al., 2016). However, scant attention has been devoted to the development of an optimal human resources framework that integrates these variables, their interrelationships, and temporal dynamics. While some studies have focused on optimizing quantitative organizational data, particularly financial metrics, such as profit and loss statements, Amrutha and Geetha (2020) underscored the limitations of relying solely on such metrics to gauge organizational productivity.

Shahreki et al. (2019) emphasize the need for systematic integration of these factors into optimization frameworks and highlighted the importance of identifying optimal timeframes for employee deployment to maximize productivity. Battini et al. (2022) have demonstrated the efficacy of multi-objective optimization techniques in human resource management. Building on their research, this study proposes a model that not only optimizes job rotation schedules but also accounts for diverse employee characteristics and temporal variations. The primary aim of this research is to create a job rotation model that supports the ideals of Industry 5.0, emphasizing the importance of human-centric approaches alongside advanced technologies. The study seeks to address the challenges of workforce inclusion by ensuring that job rotation strategies not only enhance productivity but also foster diversity and equity within organizations. Similarly, Prunet et al. (2024) investigate the mathematical programming techniques used to integrate human factors into optimization models and discuss new suggestions on how to suitably integrate human factors in OR problems encountered in logistics and manufacturing systems. While the existing literature underscores the qualitative benefits of job rotation, there is a notable gap in quantitative methodologies to optimize this process. Biorhythm analysis offers a scientific approach to understanding individual productivity cycles, aligning task assignments with performance periods (Saputra & Tjahjono, 2024). Saputra and Tjahjono (2024) systematically analyze the trends and patterns in academic publications pertaining to job rotation satisfaction. The study aims to identify key research developments, influential authors, significant journals, and thematic areas within the literature from various sources. By doing so, the researchers seek to map the evolution of knowledge in this area and highlight gaps for future investigation. Artificial Neural Networks (ANN), known for their predictive analytics capabilities, can further enhance this by modeling complex patterns in employee performance data (Syed et al., 2023). Syed et al. (2023) explore how AI can be integrated into human resource management (HRM) to optimize various processes, improve decision-making, and enhance overall organizational efficiency. The study seeks to demonstrate the potential benefits of leveraging AI in HR practices, such as recruitment, training, performance evaluation, and employee engagement.

2.4. Current Gaps in Literature

The implementation of a job rotation model raises several questions, the most challenging of which concerns the timing and frequency of job rotations and employee shifts to ensure that employees are optimally assigned to the available roles (Shafie et al., 2024). A job rotation model that accounts for the fluctuational changes in employees' mental and physical characteristics—i.e., their biorhythms—and aligns rotations with the required competencies for each job does not currently exist in the literature. In this study, we propose an algorithm for extracting and predicting employees' biorhythm cycles and optimizing their job rotations using an artificial neural network (ANN) algorithm. The ANN algorithm is selected to enhance the mathematical models of the extracted biorhythm cycles by continuously optimizing them with the integration of new data. In conclusion, the existing body of literature on job rotation optimization primarily emphasizes the alignment of employee competencies with job requirements, largely overlooking the dynamic nature of employee performance influenced by physiological and psychological fluctuations, known as biorhythms. Current models fail to integrate these fluctuating variations in employee characteristics with job rotation strategies. Additionally, while Artificial Neural Networks (ANN) have been recognized for their predictive capabilities in various domains, their application in optimizing job rotation by incorporating biorhythm data remains unexplored.

To date, no research has developed a comprehensive model that combines biorhythm analysis with ANN to predict and optimize job rotation schedules. Such a model could provide a more adaptive and personalized approach to job rotation, aligning task assignments with employees' performance periods. This study seeks to address this critical gap by proposing a novel, integrative framework that leverages ANN and biorhythm analysis to enhance job rotation practices, thereby contributing to the advancement of human resource management methodologies.

3. Research Methodology

This Section introduces the materials and the method adopted for the analysis of the person-job fit optimization problem based on biorhythm cycles. The person-job fit is defined as the assignment of the workers to the workstations considering the competencies and the physical characteristics of the working population, and the workstation requirements.

The proposed methodology and the Artificial Neural Networks (ANN) model in this paper improve the previous research on the design of job rotation schedules. Specifically, research by Botti et al. (2021) was based on a generic working population and the focus is on the integration of an aged workforce as well as the related risk factors during the design of job rotation schedules. Their model includes both physical and psychosocial factors related to ageing and work, as visual acuity, responsiveness, muscle tone and strength. Two different objective functions drive the optimization problem, i.e., the person-job fit and the movement turnover. These researches, focusing on a specific group of employees with similar static parameters, models and optimizes exposure to job-related risks.

The primary goal of this study is to extract employees' biorhythm patterns using previous data analysis and, through optimizing job requirements and employee performance, providing an optimized job rotation schedule. By employing artificial neural network (ANN) methodologies and training cycles, this approach predicts the dynamic capabilities of employees. This allows for the flexibility to update and adjust the extracted biorhythm patterns by incorporating new data and tracking changes in the physical and mental characteristics of employees.

This study was conducted in the packaging section of a poultry slaughterhouse. According to the reports, during peak production, 6,000 chickens are slaughtered per hour. The packaging section includes three workstations: bagging, sealing, and transferring to cold storage. In each workstation, there are two groups, each including three workers.

A set of personal skills and competencies characterize each worker, represented by *w*. Similarly, each workstation, represented by s, requires different abilities to perform the specific tasks. The proposed mathematical model tackles the person-job fit problem considering three items of competencies and characteristics, related to the specific characteristics of workers and workstations. Moreover, each workstation activity is analyzed according to a scoring system for the workstation assessment, which is reported in Table 1. The workstation assessment investigates the physical and the mental (focusing and relational) requirements. The scores in Table 1 range from 1 to 10. A score of 1 identifies a low physical and the mental capacity requirement, while the score 10 refers to workstations requiring high physical and the mental capacity.

The same scoring system is used for the worker assessment, describing the physical and the mental capacities of workers by a difference between worker performance and production capacity per hour in the peak production days (Table 2). Scores for worker assessment range from 1 to 10, increasing when capacity levels are high.

The model input describes the characteristics of workers and workstations. Table 3 resumes the notations for the model formulation.

Table 1. Workstations Assessment

Index	Workstation	Physical Score	Mental Score
1	Bagging	2.215	1.85
2	Sealing	3.414	8.637
3	Transferring to cold storage	9.601	4.36

Table 2. Workers' Assessment

Diff.	<-12.5%	-12.5 -10%	-10 -7.5%	-7.5 -5%	-5 -2.5%	-2.5 0%	0 2.5%	2.5 5%	5 7.5%	>7.5%
Worker Score	1	2	3	4	5	6	7	8	9	10

Table 3. Indices, Parameters and Functions for the Model

Indices	
w	Worker Index
s	Workstation Index
Parameters	
P	Physical Score
I	Mental Score
M	Worker Score
t	Time (Day)
Functions	
F (w,s)	Discrepancy between worker and workstation Capacity Function
P (w,t)	Worker Physical Capacity Function
I (w,t)	Worker Mental Capacity Function
S (t)	Sum of Workers Capacities Function

3.1. Mathematical Model

The following Equation introduces the person-job fit (*F*), for worker (*w*) and workstation (*s*):

$$F(w,s) = \left|(P_s + I_s) - 0.1(P(w,t) + I(w,t))\right|$$

F(w,s) includes the analysis of the worker (*w*) capacity to satisfy the demand level of workstation (*s*) and describe the fit between the worker, (*w*), and the workstation, (*s*), in terms of the physical and the mental capacities. The ultimate goal of this model is to optimize the objective function by minimizing the discrepancy between the job's requirements and the selected worker's capacity to perform that job.

The following conditions identify the operation assumptions for the model in this paper:

- Each job is assigned to a single employee, and conversely, each employee is tasked with only one job.
- the workstations are positioned in the same production area and the rotation of the workers between the workstations during the work-shift causes no interruptions to the working process.
- no extra time or interruptions are necessary for the workstation set-up and each workstation may accommodate any worker.
- each worker may perform all the demanded movements, with varying levels of ability and no additional training.

3.2. Neural Network Model

Architecture and Training: The neural network's architecture is designed to process and integrate diverse data types—behavioral metrics and biorhythm cycles—ensuring that the job rotation schedules are optimized not only for current productivity but also for anticipated future performance. The network uses a multi-layer perceptron architecture with input, hidden, and output layers. The input layer receives data on behavioral metrics and biorhythm cycles, the hidden layers process this information to identify complex patterns, and the output layer predicts the optimal job rotation schedules.

The network uses supervised learning techniques, where historical data on job rotations and their outcomes are used to train the model. The training process involves multiple iterations to minimize prediction errors and improve the model's accuracy in forecasting optimal job rotations. During training, the model adjusts its weights and biases based on the error between predicted and actual outcomes, gradually improving its predictive capability.

Validation and Testing: The model's performance is validated through a series of simulations and real-world pilot tests within the organization. These tests involve comparing the outcomes of job rotations planned using traditional methods versus the neural network-based method. workers scores are used to evaluate the effectiveness of the proposed approach.

Figure 1 illustrates the designed neural network, showcasing its Training and prediction pathways. The network consists of four layers: an input layer, two hidden layers, and an output layer. The first hidden layer contains four nodes, while the second hidden layer contains six nodes, utilizing the sigmoid activation function. This specific arrangement of layers and nodes was chosen based on the oscillatory nature of the data, ensuring that the learning process yields the closest possible fit to the actual data patterns.

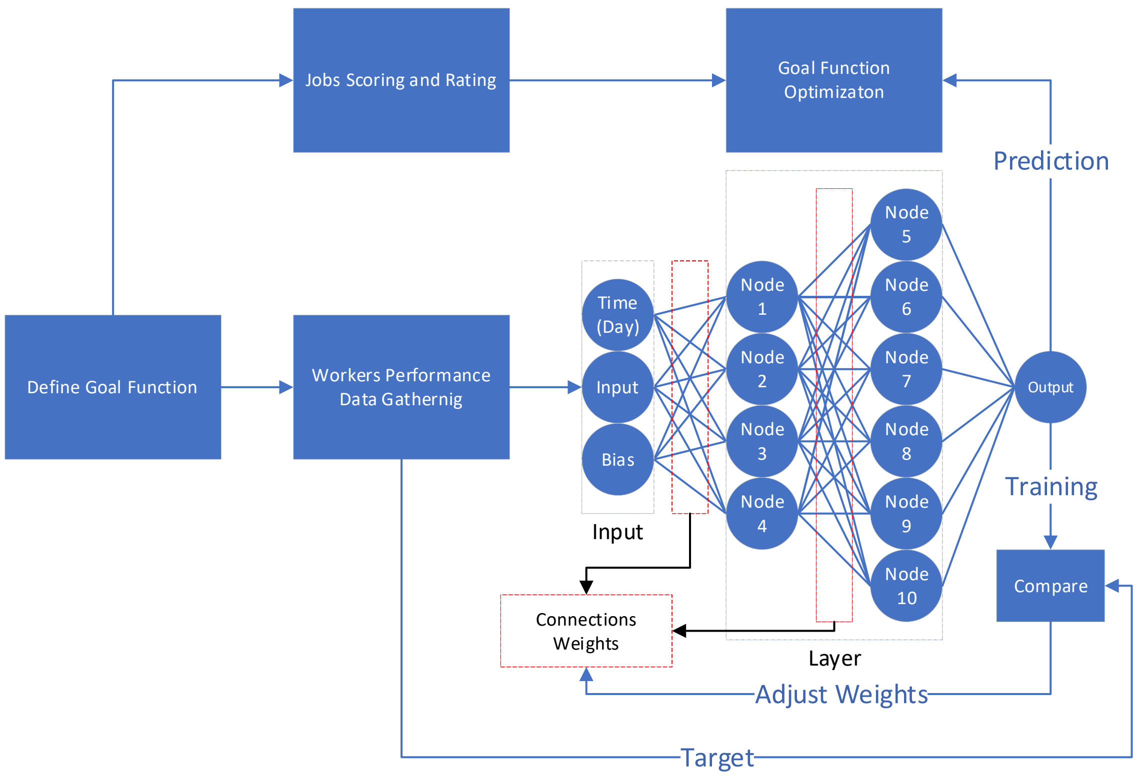

Fig. 1. Designated ANN Flowchart

3.3. Case Study

To provide the initial data set for training the neural network, evaluations from the past 540 days of worker performance were utilized. During this period, workers rotated randomly between different jobs, with each worker spending an average of 180 days in each job. The following formula was used to calculate the workers' physical and mental capacity scores:

$$P(w,t) = \left| P_2 . M_{w,2} \right|$$
$$I(w,t) = \left| I_3 . M_{w,3} \right|$$

This data set serves as the foundation for training the network, capturing the fluctuations in worker capabilities across different tasks over time.

In this model, numerical identifiers are used to denote workers and workstations, facilitating the optimization and evaluation process.

For example, A_{32} represents worker number 3 in the sealing section. Specifically, the first index A_{32} refers to the sealing workstation, and the second index indicates the worker. This coding can be effectively applied in the design of mathematical models for optimal worker assignment to different stations and for evaluating person-job fit.

$$A = \begin{bmatrix} 11 & 12 & 13 \\ 21 & 22 & 23 \\ 31 & 32 & 33 \\ 41 & 42 & 43 \\ 51 & 52 & 53 \\ 61 & 62 & 63 \end{bmatrix}$$

The proposed model is implemented using MATLAB, leveraging its robust computational and visualization capabilities. The data is pre-processed to ensure consistency and completeness before being fed into the neural network. Pre-processing steps include data normalization, handling missing values, and encoding categorical variables.

The figures below illustrate the collected data (right) alongside the modified extrapolated charts produced by the ANN (left).

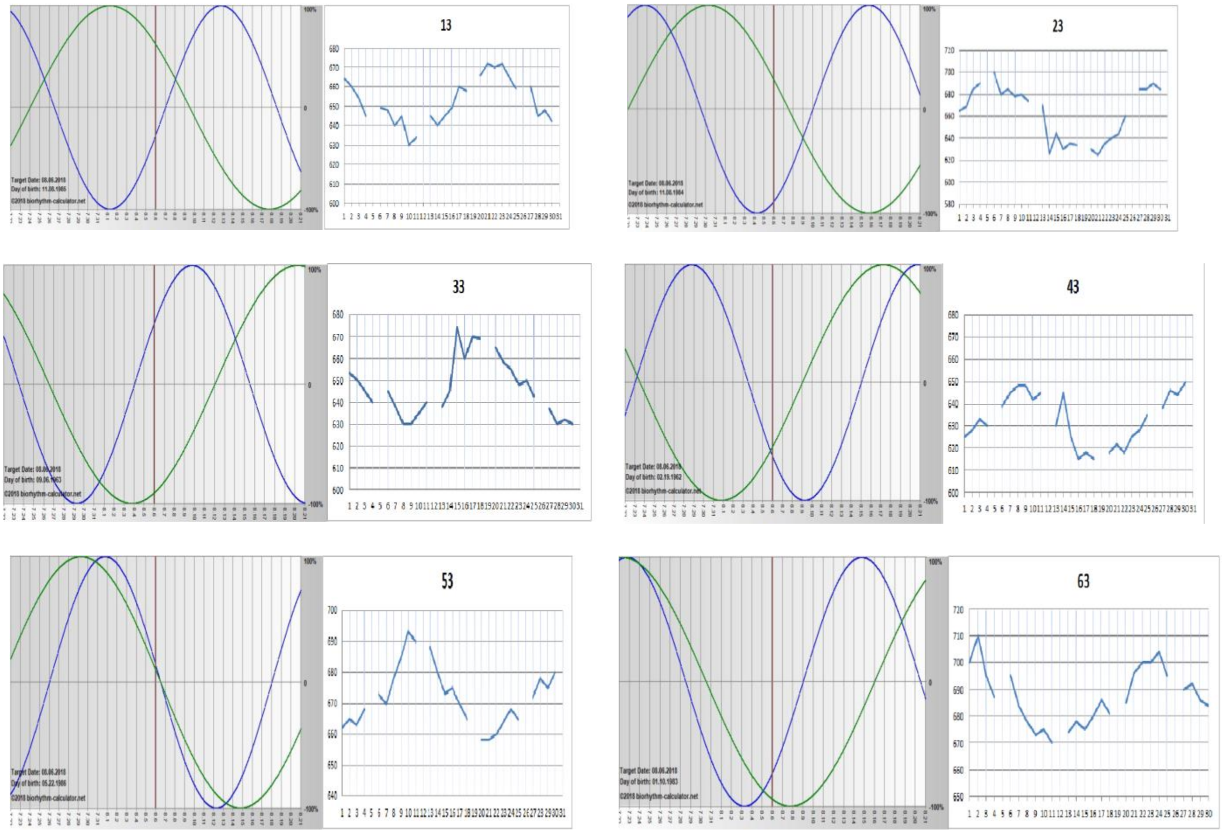

Fig. 2. Charts of Collected Data (Right) and the Modified Extrapolating Chart by ANN (Left)

Subsequently, the algorithm proceeds to assign employees to complete matrix A (assigns Workers to Job).

Following this procedure, the algorithm completes the matrix for three days as illustrated below (The letters within quotation marks represent workers):

$$A_1 = \begin{bmatrix} 'J' & 'N' & 'L' \\ 'P' & 'K' & 'B' \\ 'F' & 'D' & 'A' \\ 'C' & 'R' & 'Q' \\ 'O' & 'H' & 'M' \\ 'I' & 'G' & 'E' \end{bmatrix} \quad A_2 = \begin{bmatrix} 'B' & 'R' & 'D' \\ 'A' & 'M' & 'I' \\ 'J' & 'G' & 'L' \\ 'O' & 'K' & 'Q' \\ 'F' & 'N' & 'P' \\ 'C' & 'H' & 'E' \end{bmatrix} \quad A_3 = \begin{bmatrix} 'I' & 'R' & 'D' \\ 'B' & 'M' & 'H' \\ 'J' & 'Q' & 'N' \\ 'C' & 'K' & 'E' \\ 'F' & 'G' & 'O' \\ 'P' & 'L' & 'A' \end{bmatrix}$$

This model also provides a diagram of the function *S*. The function *S* is defined as the predicted function for the total mental and physical capacities of workers under job rotation conditions. It expresses the maximum capacity of workers in the packaging section of the slaughterhouse, assuming that workers are assigned to appropriate jobs.

In other words, the function *S* helps assess the maximum potential capacities of workers based on the optimal allocation of workers to different workstations. This assessment includes factors such as physical and mental workers and the alignment between individual capacities and job demands.

Below, you can observe the six-month extrapolated diagram of the *S* function for the packing line:

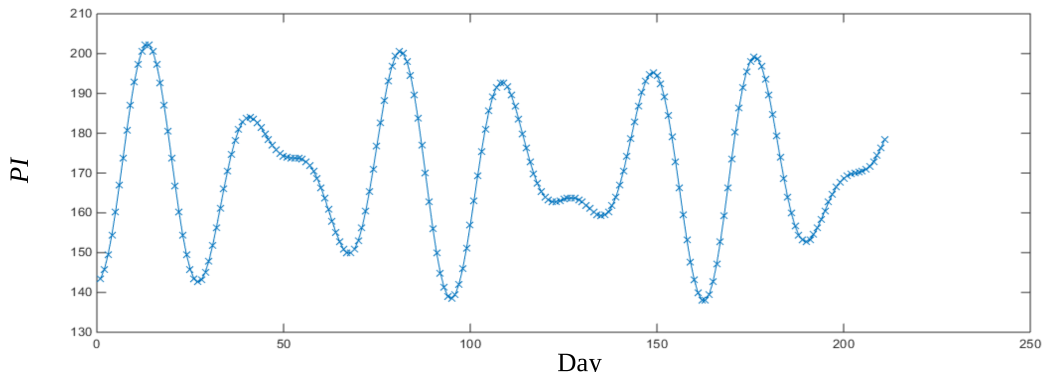

Fig. 3. 6 Month Extrapolated Diagram of the S Function

Based on the acquired diagrams, precise planning can be formulated by analyzing the capabilities of workers within the organization. These diagrams, derived from the *S* function and other relevant metrics, allow managers to develop optimized job rotation schedules that align with each worker's physical and mental capacity.

By evaluating the daily capacity of workers, production schedules can be strategically planned, ensuring that the workers are allocated to tasks that best suit their capacity.

Furthermore, to observe the periodicity, a three-year extrapolated diagram of the "S" function is generated (assuming the same employees):

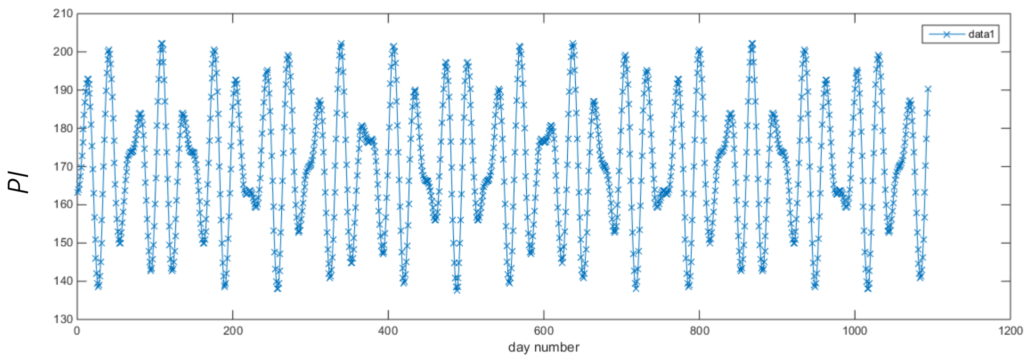

Fig. 4. 3-Year Extrapolated Diagram of the S Function

The function exhibits a periodic cycle of 756 days. It is important to note that this periodicity may vary across different organizations and departments, depending on various factors such as the nature of the tasks, workforce composition, and operational demands. The periodic nature of the function allows managers to anticipate fluctuations in worker capacity and adjust job rotation schedules accordingly to maintain optimal performance levels.

This adaptability ensures that the model remains flexible and applicable to a wide range of organizational contexts, allowing for customized planning and capacity management tailored to specific workforce and operational characteristics.

4. Discussion

This study introduces a groundbreaking framework for optimizing job rotation through the integration of biorhythm analysis and Artificial Neural Network (ANN) methodologies. By examining the mental and physical states of employees over a one-month period, the model aims to enhance productivity and job satisfaction through better job-person alignment. The findings and contributions of this study are significant and multifaceted.

Figure 5 illustrates the reports from the packaging section for the years 2020 (when job rotation was performed randomly) and 2021 (when job rotation was based on the model proposed in this study). The chart presents a significant reduction in discrepancies between the capacity levels within the packaging department, indicating greater alignment and coordination of production speeds across workers in different sections.

These results highlight that implementing the proposed model, compared to random job rotation, significantly improves workload distribution and productivity. The optimization also enhances coordination among employees, reducing fluctuations in production performance.

The integration of biorhythm cycles into job rotation planning introduces a novel quantitative approach that addresses the limitations of traditional methods. By leveraging ANN to process complex behavioral data and biorhythm cycles, the model ensures a precise alignment between job assignments and employees' optimal performance periods. This methodological advancement allows for a more tailored job rotation strategy, optimizing both individual and organizational productivity.

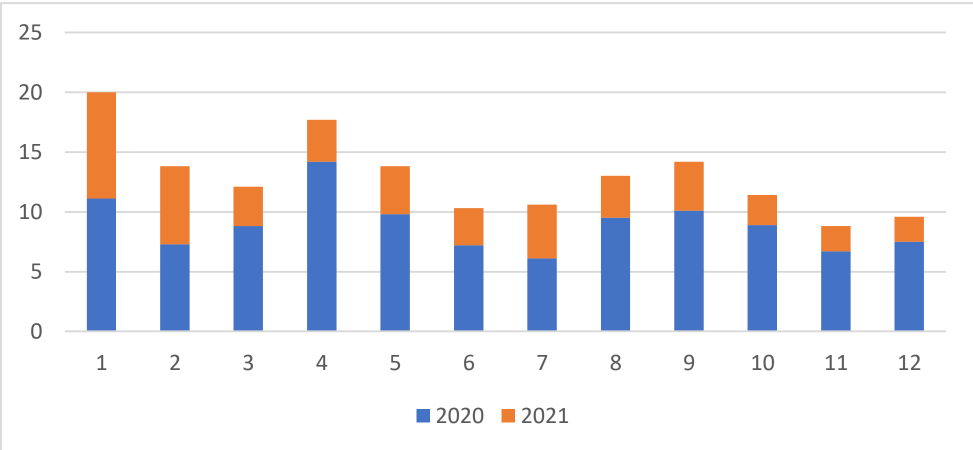

Fig. 5. Discrepancy Between Capacity of Packing Line Sections in 2020 and 2021

4.1. Compatibility with Previous Research

Previous studies have underscored the role of job rotation in improving workforce motivation, skill diversification, and overall organizational productivity (Geethanjali et al., 2024; Liang et al., 2023; Ayough et al., 2020). While these activities emphasize qualitative benefits, they often lack quantitative methodologies for optimizing job rotation schedules. This research addresses these gaps by integrating biorhythm analysis, which accounts for the cyclical physiological and psychological states of employees, with Artificial Neural Network (ANN) methodologies, recognized for their predictive analytics capabilities. This novel framework facilitates the precise alignment of job assignments with employees' optimal performance periods, addressing significant limitations in prior literature.

Battini et al. (2022) introduced a multi-objective job rotation model aimed at enhancing workforce inclusivity within the Industry 5.0 paradigm. Although their model highlights the value of workforce diversity, it does not incorporate fluctuations in employee performance. In contrast, the present study builds on such foundational research by incorporating biorhythm analysis to address performance fluctuations over time. Similarly, Botti et al. (2021) develop job rotation strategies for aged workers, but without accounting for dynamic physiological and psychological cycles. The framework proposed here extends their work by integrating these considerations, offering a more holistic approach to job rotation planning.

Ayough et al. (2020) investigate the dynamic nature of operator performance within U-shaped lean cells, focusing on sequencing and workload balancing. While their approach provides a foundation for dynamic modeling, the incorporation of ANN in this study introduces a robust mechanism for processing complex behavioral data. This integration enables predictive capabilities, refining the alignment of tasks to individual employee performance profiles beyond static methodologies.

The findings of Liang et al. (2023) demonstrate the positive effects of job rotation on employee satisfaction and performance, a conclusion further supported by this study. By leveraging biorhythm cycles, the proposed framework advances job rotation planning by addressing individual performance fluctuations and promoting equitable task distribution.

Strategic human resource management, as discussed by Geethanjali et al. (2024) and Li (2024), has been argued to enhance organizational efficiency. The framework developed in this research complements these findings by aligning production schedules with employees' peak performance periods, thereby reducing productivity fluctuations and improving overall operational effectiveness. This aligns with broader themes of workforce optimization and renewal emphasized in their work.

Syed et al. (2023) highlight the transformative potential of AI in optimizing human resource practices. This study builds on their insights by showcasing the practical application of ANN in job rotation, combining the predictive power of AI with human-centric considerations, such as biorhythm cycles. This integrative approach not only addresses traditional HR challenges but also sets a precedent for future AI-driven advancements in workforce management.

Furthermore, the bibliometric analysis conducted by Saputra and Tjahjono (2024) identified emerging trends in job rotation research, including employee satisfaction and productivity outcomes. This study contributes to these trends by providing empirical evidence that a scientifically grounded framework can outperform traditional job rotation approaches. The case study of an industrial poultry slaughterhouse demonstrates significant improvements in productivity and coordination metrics, validating the proposed framework's effectiveness.

4.2. New Insights and Contributions

The primary contribution of this study lies in its demonstration of how biorhythm analysis and ANN can be used to develop a systematic and scientific framework for job rotation. This framework goes beyond traditional methods by incorporating individual performance fluctuations into the job rotation strategy. The case study of an industrial poultry slaughterhouse packaging line indicated that this approach not only enhances productivity but also ensures equitable task distribution among employees based on their mental and physical capacities.

This research advances the literature by:

Introducing a Quantitative Approach: By utilizing biorhythm and ANN methodologies, this study provides a quantitative method for optimizing job rotation, which has been largely missing in prior research.

Improving Organizational Efficiency: The model's ability to optimize job-employee alignment based on collective abilities ensures that production periods align with workers capacities, leading to enhanced organizational efficiency.

4.3. Theoretical Contributions

The theoretical contributions of this study are manifold. Firstly, it extends the application of biorhythm theory into the realm of job rotation, providing a scientific basis for understanding how employees' physiological and psychological cycles can impact their job performance. Secondly, it leverages ANN methodologies to model complex patterns in employee performance data, offering a new dimension to the predictive analytics capabilities in human resource management.

Furthermore, this research contributes to the broader field of organizational behavior by illustrating the interplay between individual traits and job performance. By doing so, it bridges the gap between traditional human resource practices and modern data-driven methodologies, providing a comprehensive framework that can be adapted across various industries.

4.4. Practical Implications

From a practical standpoint, the implementation of this job rotation model can significantly enhance workforce management practices. Organizations can use this model to develop more effective job rotation schedules. The model also provides managers with a tool for strategic planning, enabling them to align production periods with workers capacities.

Managers can use the model to create dynamic job rotation schedules that respond to real-time changes in employee performance and organizational needs, leading to more effective resource allocation.

The dual-level optimization framework ensures a more equitable distribution of tasks among employees by taking into account their varying physical and mental states. This equitable approach not only fosters a sense of fairness and inclusivity within the workplace but also leverages the diverse strengths of the workforce. By systematically identifying suitable candidates for job rotations based on behavioral parameters and biorhythm cycles, the model ensures that tasks are assigned in a manner that optimally utilizes the collective capabilities of the workforce.

By incorporating predictive analytics into workforce planning, organizations can anticipate future workforce needs and proactively address potential issues, leading to more resilient and agile operations. The application of ANN methodologies in analyzing complex behavioral data and biorhythm cycles provides managers with a powerful tool for strategic workforce planning. The predictive capabilities of the neural network enable managers to forecast the most effective job rotations and align them with organizational objectives and production periods.

Our model exemplifies the potential of data-driven decision-making in human resource management. By utilizing continuous performance monitoring systems, employee surveys, and wearable health monitoring devices, organizations can collect comprehensive data on employee behaviors and biorhythm cycles. The neural network's ability to process and analyze this data facilitates informed decision-making, allowing organizations to develop more effective and responsive job rotation schedules. This data-driven approach not only enhances the precision of job assignments but also provides a scalable and adaptable framework that can be customized to meet the specific needs of different organizational contexts. Furthermore, the transparency and objectivity of data-driven decisions can improve employee buy-in and reduce resistance to job rotation initiatives.

The dynamic nature of the proposed job rotation model allows it to adapt to organizational changes and evolving workforce needs. As organizations grow and restructure, the model can continuously update and refine job rotation schedules based on real-time data and changing employee profiles. This adaptability ensures that job rotations remain relevant and effective, even in the face of organizational shifts, such as mergers and acquisitions, or changes in business strategy. By maintaining alignment with current organizational goals and employee capabilities, the model supports sustained productivity and operational excellence.

4.5. Limitations and Future Research Directions

Despite its innovative approach and significant contributions, this study has several limitations that warrant consideration.

Single Case Study Focus: The primary limitation is the focus on a single case study within an industrial poultry slaughterhouse packaging line. While the findings are promising, they may not be universally applicable across different industries or organizational contexts. The specific operational characteristics of a poultry slaughterhouse might influence the outcomes, thus limiting the generalizability of the results. Future research should aim to replicate this study in various sectors, such as manufacturing, healthcare, and service industries, to validate the model's applicability and effectiveness in diverse environments.

Limited Scope of Biorhythm Factors: While this study integrates physical and mental states into the job rotation model, it does not comprehensively consider other critical factors such as emotional well-being and external stressors. While emotional states, for example, can significantly impact job performance and employee satisfaction, they are not included in the current model. Future studies should incorporate a broader range of biorhythm factors, including emotional and social dimensions, to provide a more holistic understanding of employee performance dynamics.

Data Privacy and Ethical Concerns: The use of personal biorhythm data raises important ethical considerations. Although the model demonstrates significant potential in optimizing job rotations, the collection and utilization of sensitive personal data must be handled with strict adherence to privacy laws and ethical standards. Ensuring employee consent and data confidentiality is paramount. Future research should address these ethical issues, possibly developing frameworks for safeguarding employee data and establishing clear guidelines for ethical data use in workforce management.

Dynamic Organizational and Environmental Factors: The model currently assumes relatively stable organizational conditions and employee roles. However, in dynamic and rapidly changing environments, such as those characterized by high turnover rates or frequent organizational restructuring, the model's predictive accuracy may be compromised. Future studies should investigate the robustness of the model under such dynamic conditions and explore ways to enhance its adaptability to rapidly changing organizational landscapes.

5. Conclusion

In conclusion, this study presents a pioneering approach to job rotation optimization by integrating biorhythm analysis and ANN methodologies. This approach not only addresses existing gaps in the literature but also offers practical solutions for enhancing organizational efficiency and employee well-being. By providing a dynamic, data-driven model, this research contributes to the development of more effective job rotation strategies that can adapt to the fluctuating performance. Future research should continue to build on this framework, exploring its application in diverse contexts and addressing its ethical implications. This research underscores the importance of considering both employee capabilities and organizational demands in the development of effective job rotation programs.

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