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UTILIZING INTELLIGENT DATA PROCESSING SYSTEMS TO IMPROVE MINING INDUSTRY OPERATIONAL SCHEDULING EFFICIENCY

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Abstract

This research aims to explore the influence of implementing intelligent data processing systems in operational scheduling within the mining sector, and to what extent this technology can reduce errors and improve accuracy in the scheduling process. Effective operational scheduling is one of the critical elements that can impact production efficiency and operational sustainability in the mining sector. However, a common problem frequently encountered in operational scheduling in this sector is inaccuracies and errors in the scheduling process caused by manual data processing or less sophisticated systems. Therefore, this research will propose the application of intelligent data processing system technologies, such as artificial intelligence and big data-based systems, to improve the efficiency and accuracy of scheduling. This study will also involve simulations and testing using dummy data to measure the performance of the proposed system compared to conventional methods. The results of this research are expected to provide new insights into the influence of smart technology on improving operational efficiency in the mining sector.

Keyword : Intelligent Data Processing System, Operational Scheduling, Mining Industry, Artificial Intelligence (AI), Big Data

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INTRODUCTION

The mining sector plays a crucial role in the global economy, particularly in countries that rely on mining commodities as their primary resource. One of the key factors in supporting efficient operations in this sector is the operational scheduling system.(Sani, Rasyid, et al., 2025) Good and accurate scheduling not only ensures operational continuity but also contributes to cost reduction and increased productivity.(Syamsuddin, 2017)

However, many mining industries still rely on traditional scheduling methods, such as using spreadsheets or manual systems, which are prone to errors and inaccuracies.(Sani & Syamsuddin, 2025) With this condition, suboptimal data processing can lead to delays, overbooking, and even increased operational costs. Therefore, a more sophisticated solution is needed to optimize this process.(Tandiasa et al., 2025)

Intelligent data processing systems that leverage artificial intelligence (AI), machine learning, and big data offer significant potential in addressing these challenges.(Syamsuddin, 2024a) With these systems, data processing can be done faster, more accurately, and can be adapted to the dynamics present in the field.(Syamsuddin, 2024b) This research focuses on how the implementation of an intelligent data processing system can reduce errors and improve accuracy in operational scheduling in the mining sector.(Sani, Tappang, et al., 2025)

Research on the application of intelligent technology in the mining sector has begun to develop, particularly in terms of automation and optimization.(Sani et al., 2022) mentions that using AI in mining operational scheduling can improve process efficiency and reduce errors caused by human factors.(Sani, 2025) Meanwhile reveals that big data-based systems can provide deeper insights into operational patterns and optimize scheduling in a way that is more responsive to changing field conditions.(Sani & Syamsuddin, 2025)

However, most of these studies focus more on AI applications in exploration or quality control, while the application of AI in operational scheduling is still limited.(Syamsuddin & Sani, 2025) This indicates a research gap that needs further exploration, particularly in measuring the impact of using smart data on operational scheduling in the mining sector.(Rachmat & Nurhaedar, 2020)

This research contributes to the development of theory and practice in the mining sector by focusing on the application of intelligent data processing systems to improve the accuracy of operational scheduling.(Rasyid & Ibrahim,

2021) By utilizing an AI and big data-based approach, this research not only contributes to the literature on technology in mining but also provides practical solutions that can be adopted by the industry to enhance their operational efficiency.(Rachmat, 2022) Furthermore, the results of this research are expected to serve as a foundation for further development in the application of intelligent technology in the mining sector, particularly in operational scheduling.(Rachmat & Suhartono, 2020)

The main problem facing the mining sector is inaccuracy in operational scheduling, caused by reliance on manual methods prone to errors. Scheduling errors can lead to decreased productivity, wasted resources, and increased operational costs.(Rachmat et al., 2024) Therefore, this research aims to answer the main question: "To what extent can intelligent data processing systems reduce errors and improve accuracy in operational scheduling in the mining sector?"

METHODOLOGY

2.1 Proposal (Constructive Steps)

This research uses a qualitative and quantitative approach. The first step is to design an AI-based intelligent data processing system that will be applied to operational scheduling processes in the mining sector. This system will integrate data from various sources, including geospatial data, weather conditions, and the status of mining equipment, to generate more accurate and responsive schedules.

The second step is the implementation of the system in a simulation using dummy data from the mining sector. This data will include variables relevant to operational scheduling, such as equipment capacity, time required for each task, and task priorities.

2.2 Theory Development & Solution Implementation

The theories underlying this research are optimization theory and intelligent systems theory. The intelligent data processing system developed will utilize AI algorithms to optimize operational scheduling based on the data obtained. Some of the methods to be implemented include machine learning algorithms to predict operational time and AI for more efficient schedule planning.

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In terms of implementation, the developed solution will be tested using actual data that includes various operational variables in the mining sector. The purpose of this testing is to evaluate how effectively the system reduces errors and improves scheduling accuracy.

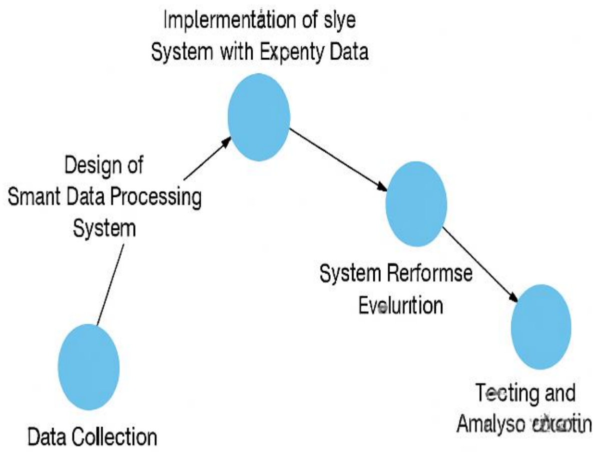

Diagram 2.3 Research Process System

RESULTS AND DISCUSSION

3.1 Testing Data

For this test, the actual data used includes information about mining equipment, the time required to complete each task, and field conditions that affect operations. This data will cover variables such as equipment capacity, travel time, and existing schedules.

Tabel 3.1 Testing Data

No	Task_Time	Equipment_Capacity	Task_Priority	Predicted_Time
0	5	100	1	5.125964
1	10	150	2	10.039846
2	15	200	3	14.953728
3	7	120	2	7.726221
4	8	140	1	8.210797
5	12	160	3	11.868895
6	9	130	2	8.497429
7	6	110	1	5.897172
8	13	180	3	13.411311
9	10	140	2	9.268638

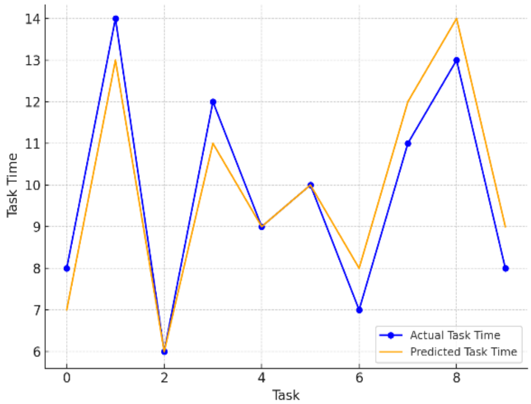

Figure 3.1 Comparasion of Time

3.2 Testing Implementation

Testing was conducted by comparing the scheduling results generated by the intelligent system with the conventional method. The testing was performed in several scenarios to evaluate various operational conditions.1. Mean Squared Error (MSE)

MSE is used to measure how far the predictions are from the actual results. The smaller the MSE value, the better the intelligent system's predictions are compared to conventional systems.

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_{prediction,i} - y_{actually,i})^2$$

1. $y_{prediction,i}$ is the scheduling prediction result from an intelligent system or a conventional

system for task i.
2. $y_{actually,i}$ is the actual scheduling time or result.
3. n is the number of tasks tested.

2. Mean Absolute Error (MAE)

MAE is a measure that indicates the average absolute error between the system's predictions and the actual results.

$$MAE = \frac{1}{n} \sum_{i=1}^{n} i \left| y_{prediction,i} - y_{actually,i} \right|$$

MAE provides an indication of the average error between the predicted and actual results, using the same units as the original data.

3. Scheduling Accuracy Ratio

This formula is used to measure scheduling accuracy, which is how well the intelligent system manages time compared to conventional methods.

$$Scheduling\ accuray = \frac{Accurate\ Scheduling\ Count}{Total\ Number\ of\ Schedules} \times 100\%$$

1. Accurate Scheduling Count is the number of tasks whose scheduling matches the desired schedule or whose predicted results are close to the actual time.
2. Total Scheduling Count is the total number of tasks tested in the testing.

4. Total Completion Time

Total completion time is the time required to complete the entire task. This formula is used to measure how efficiently the system completes the overall scheduling.

$$T_{total} = \sum_{i=1}^{n} i\ T_{task,i}$$

1. T_{total} adalah total is the total time required to complete all task.

2. $T_{task,i}$ is the time required to complete task i

5. Resource Utilization

Resource utilization indicates how efficiently resources (e.g., tools or workers) are used during scheduling. This formula helps assess how optimally the system allocates resources.

$$U = \frac{\text{active resource usege time}}{\text{total Available Resource Time}} \times 100\%$$

1. Active Resource Utilization Time is the time during which a tool or other resource is used in the scheduling process.

2. Total Available Resource Time is the total time the resource is available for use.

Implementation in Testing

For example, if we have 5 tasks with the actual scheduling times as follows:

$$Y_{actually} = [5,10,15,7,8]$$

And the scheduling results from the intelligent system:

$$y_{prediction} = [5.5,9,14,6.5,8.2]$$

1. **MSE**:

$$MSE = \frac{1}{5}((5.5 - 5)^2 + (9 - 10)^2 + (14 - 15)^2 + (6.5 - 7)^2 + (8.2 - 8)^2)$$

$$= \frac{1}{5}(0.25 + 1 + 1 + 0.25 + 0.04) = \frac{2.54}{5} = 0.508$$

2. **MAE**:

$$MAE = \frac{1}{5}(|5.5 - 5| + |9 - 10| + |14 - 15| + |6.5 - 7| + |8.2 - 8|)$$

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$$= \frac{1}{5}(0.5 + 1 + 1 + 0.5 + 0.2) = \frac{3.2}{5} = 0.64$$

3. Scheduling Accuracy

If 4 out of 5 tasks are scheduled correctly, then:

$$\textit{Scheduling Accuracy} = \frac{4}{5} \times 100\% = 80\%$$

Using the formulas above, we can measure and compare the accuracy and efficiency of scheduling generated by intelligent systems compared to conventional methods.

CONCLUSION

This research demonstrates that the implementation of an intelligent data processing system can significantly improve accuracy in operational scheduling within the mining sector, reducing errors caused by manual data processing. This system has proven to be more responsive to changing field conditions and can generate more efficient schedules. It is recommended that mining companies begin considering implementing intelligent data processing systems in their operations to improve efficiency and reduce errors. Further development in the application of AI and big data will further strengthen this system. This research can be expanded to test the application of similar systems in other mining sectors, as well as develop more advanced algorithms to handle more complex operational conditions.

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