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DEEP Q-NETWORK ANALYSIS IN OPTIMIZING DATA PROCESSING FOR DECISION MAKING ON FUEL EXPENDITURE FINANCE

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ABSTRACT

As we know, Diesel fuel or also called Solar is a fuel used for diesel-engined motor vehicles, which are generally used in public transportation vehicles or commercial vehicles. In addition, it is also used in diesel for industry. Solar energy is obtained from petroleum refining. In addition to being a fuel, diesel also functions as a lubricant in diesel engine components. In managing the fuel budget for companies or agencies that have high operational needs, decisions regarding the allocation of funds and fuel purchases are very important. Inefficient or unplanned fuel purchases can result in waste and reduce profitability. Therefore, an optimal decision-making system is needed at PT. Deztonindo, which can accurately predict fuel needs and adjust the budget according to the company with the right price and market demand. This study uses a literature review method with the Deep Q-Network (DQN) method. The number of samples in this study is 2559 data with 10 test data. With a reduction in idle time of up to 50%, idle fuel consumption is reduced by 18 liters, increasing efficiency from 0.88 km / liter to 1.28 km / liter, or an increase of 45.5%. After optimization, there was a decrease in average fuel consumption of 20%, which had a direct impact on saving operational costs in a year for the diesel fuel purchase budget. The existence of this decision system can overcome the obstacles to obtaining accurate results for the diesel fuel purchase budget, to minimize the level of conditions that occur

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INTRODUCTION

In managing the fuel budget for companies or agencies that have high operational needs, decisions regarding the allocation of funds and fuel purchases are very important.(Rasyid et al., 2024) Inefficient or poorly planned fuel purchases can result in waste and reduce profitability. (Heryana et al., 2020)Therefore, an optimal decision-making system is needed at PT Deztonindo, which can accurately predict fuel needs and adjust the budget according to company needs with price fluctuations and market demand(Nainggolan & Nasution, 2023).

One approach that can be used to improve the efficiency of decision making in the management of bio Solar fuel spending at PT Deztonindo is to utilize Deep Q-Networks (DQN). (Muit Sunjaya et al., 2024)DQN is a reinforcement learning technique that combines intelligent decision making with deep learning capabilities to predict and optimize actions based on very large data. (NUR, 2020)With DQN, the system can learn from past experiences to make optimal decisions under changing conditions.(Zen Munawar & Novianti Indah Putri, 2020)

Deep Q-Networks (DQN) enable reinforcement learning systems to learn complex tasks by estimating action-value functions using neural networks.(Sinaga & Sinaga, 2024) reinforcement learning (RL) is a type of machine learning where the system,(Shinta Dewi & Dewayanto, 2024) learns to make decisions by interacting with the environment. the system receives feedback in the form of data or inputs and aims to maximize cumulative information over time.(Raup et al., 2022)

Deep Q-Networks (DQN) combine RL with deep learning, which allows the system to learn from high-dimensional inputs,(Febrian & Geni, 2024) such as images, and handle complex tasks. Deep Q-Networks have shown great potential in reinforcement learning(Oktaviarosa, 2024)

The application of DQN in the management of fuel expenditure based on bio diesel can help maximize the efficiency of fuel expenditure, (Mardianto et al., 2023) minimize waste, and make decisions that are more adaptive to fluctuations in fuel prices and consumption.(Syira et al., 2023) In this context, DQN can be used to forecast fuel usage, the utilization of DQN is expected to increase efficiency, reduce costs, and provide a competitive advantage in the financial management of fuel expenditures.(Kushariyadi & Bambang Sugito, 2022) This research aims to explore and analyze in depth how the Deep Q-Network algorithm can be implemented and optimized to process financial data on fuel expenditures, resulting in more effective and efficient decision making.(Arifin et al., 2023)

METHODS

This research was conducted at PT Deztonindo Persada in order to obtain accurate data which is the focus of the research because it has diversity in the filling population and provides various facilities that will be the center of attention in this study and this location was chosen because it has an important role in helping the author to complete this final project. in the time span of the odd semester of the 2024-2025 academic year to the even semester of the 2024-2025 academic year. This time selection is based on filling.The focus of the research included observations of ongoing manual processes, stakeholder engagement, and analysis of information technology needs and readiness to support digitization. The research also includes an evaluation of the Company's bio diesel fuel usage and finances.

2.1 Target / Research Subject

This research framework is organized systematically to ensure that the research can proceed in a planned manner and produce outputs that are relevant to the research objectives. The following is a research framework based on the scope of study at PT Deztonindo:

Table 1. research framework

Preparation (Problem Identification, Primary Data Study, Research Method Design)

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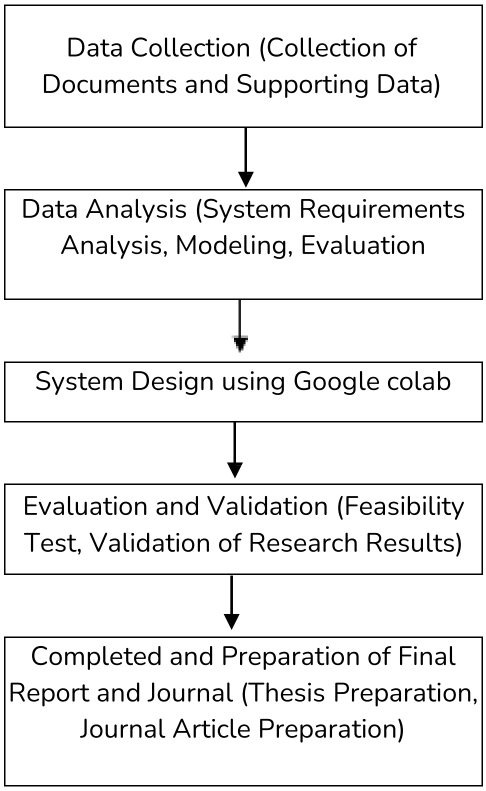


Based on the diagram table above, the research procedure can be explained as follows

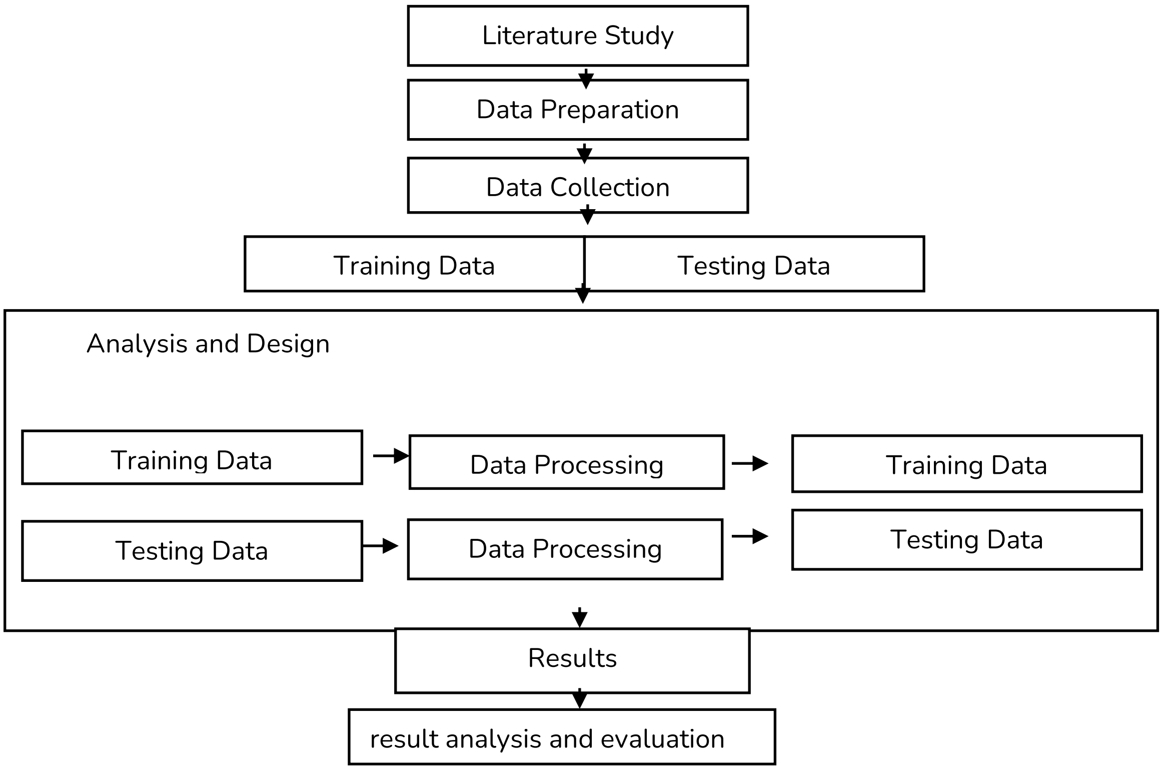
1. Preparation
   The research began with a literature review to understand the basic concepts of diesel fuel use. At this stage, the research method was also designed to determine the appropriate approach, including the preparation of instruments such as interview guides, questionnaires, and observation sites.
2. data collection
   Direct observation was conducted at the company to understand the ongoing manual process, including the flow of charging, recording, and constraints faced. In addition, additional data was collected from official documents, such as diesel usage reports, mixer route reports, operational hours and mixer travel kilometers, which support further analysis. This stage aims to obtain comprehensive data as the basis for system development.
3. Data analysis
   the results of data collection are processed and analyzed to understand the needs of the system and the gap between the current condition and the expected ideal condition.
4. system design
   The analysis results are translated into a more concrete system design. The google colab system is structured to cover various aspects, such as a more stable business process of using fuel, a more efficient data structure, and a more efficient system.
5. evaluation and validation
   The results of this evaluation are used to improve the use of diesel fuel so that it can be implemented effectively and provide maximum benefits for the company.
6. preparation of the final report
   This report covers all stages of the research, from planning to evaluation of results, as well as recommendations for optimizing the use of designed fuel expenditure finances. Journal articles

are prepared for publication in scientific journals, with the aim of disseminating research results to the academic and practitioner community.

2.2 Data analysis techniques

This research focuses on the budget for the use of financial purchases of diesel fuel with a diesel price of Rp 9,970 per liter to minimize finances at PT Deztonindo. The research design includes the following

Table 2. Research Design



The stages of this research design include

1. Studi Literatur
   at this stage using research methods is collecting, analyzing information from various sources contained in the research company.
2. Data Preparation
   at this stage prepare raw data (Raw Data) into a more structured form so that the data is easier to use.
3. Data Collection
   At this stage the data after being collected and more structured, data separation will be carried out, namely training data and test data. Then in this process the training data and test data will go through the data processing process to get the results of the training data.
4. Result
   at this stage will be known the results of the efficient use of diesel fuel in the mixer fleet.
5. result analysis and evaluation
   at this stage will be re-analyzed and re-evaluated whether the results are satisfactory or not will be adjusted to the company.

Collecting information and theories relevant to the research from various sources, such as books, journals, articles, and websites. Literature studies were conducted to support the theoretical basis and data analysis in this study.

RESULTS AND DISCUSSION

This chapter also presents the results of applying the DQN model in fuel consumption optimization of mixer trucks, evaluates its impact on operational efficiency, and analyzes the performance of the model in various scenarios. In addition, the technical implementation of the DQN model in Python is discussed, including data preprocessing, model training, and convergence analysis. Visualizations in the form of fuel consumption comparison graphs, model decision distribution, and reward function result plotting also support the analysis in this study.

Dataset Description

This data was collected to represent the real conditions of a truck trip involving factors such as load, distance traveled, idle time, and traffic conditions. The variables in this dataset reflect the characteristics that become inputs in the Deep Q-Network (DQN) model, which aims to optimize fuel consumption based on more efficient decision making. The following is a sample of 10 truck trip data used in this study Table 3 Sample mixer truck data dataset

Table 3. Sample mixer truck data dataset

No.	Truck Code	Initial Fuel	Final Fuel	Mileange (km)	Idle Time (jam)	Payload (kubik)	Traffic Index
1	H-190	100	78	24	2	10	0.0
2	H-121	100	86	17	1	7	1.0
3	F-221	100	90	26	3	5	0.5
4	F-881	90	47	25	2	3	0.5
5	F-811	100	96	1	1	9	1.0
6	F-251	100	92	27	1	8	1.0
7	H-102	105	41	36	2	7	0.0
8	H-112	100	38	36	3	7	0.5
9	H-663	100	53	27	1	6	1.0
10	F-723	100	73	14	2	8	0.0

Based on table 3.1, it can be seen that variations in fuel consumption are based on distance traveled, idle time, load carried, and traffic conditions. For example, truck H-190 consumes 22 liters of fuel to travel 24 km, with an idle time of 2 hours and a load of 10 cubic feet, while truck H-121 consumes 14 liters of fuel to travel 17 km, with a traffic index of 1.0 indicating heavy traffic.

Fuel Efficiency Calculation

The calculation of fuel efficiency is obtained by finding the relationship between distance and total fuel used. Fuel efficiency is calculated by the formula:

$$\text{fuel efficiency} = \frac{Range}{Fuel\ Consumpsion}$$

Table 2 is the result of the direct efficiency calculation obtained by dividing the distance traveled by the mixer truck with the total fuel used during the round trip.

Table 4. Fuel efficiency calculation

No.	Truck Code	Mileage (km)	fuel consumption (liter)	Fuel Efficiency (km/liter)
1	H-I90	24	22	$\frac{24}{22} = 1.09$
2	H-121	17	14	$\frac{17}{14} = 1.21$
3	F-221	26	10	$\frac{26}{10} = 2.60$
4	F-881	25	43	$\frac{25}{43} = 0.58$
5	F-811	1	4	$\frac{1}{4} = 0.25$
6	F-251	27	8	$\frac{27}{8} = 3.38$
7	H-102	36	64	$\frac{36}{64} = 0.56$
8	H-112	36	62	$\frac{36}{62} = 0.58$
9	H-663	27	47	$\frac{27}{47} = 0.57$
10	F-723	14	27	$\frac{14}{27} = 0.52$

From table 2, it can be seen that the fuel efficiency varies for each trip. Truck F-251 has the highest fuel efficiency with 3.38 km/liter, while truck F-811 has the lowest efficiency with 0.25 km/liter.

Efficiency Result Condition

This is done by comparing Fuel Difference-the difference between Moving Fuel Used and Estimated Moving Fuel Used-and Efficiency, which is calculated from the ratio of mileage to total fuel consumption. These values are then used to categorize vehicles into specific categories, such as Very Economical, Neutral, Slightly Wasteful, Wasteful, Very Wasteful, or Needs Investigation.

Table 5. Efficiency yield condition calculation

No.	Kode Truk	Jarak (km)	Idle Time (jam)	Muatan (kubik)	Indeks Lalu Lintas	Fuel Used	Idle Fuel Used	Moving Fuel Used	Estimated Moving Fuel Used	Fuel Difference	Efficiency	Condition
1	H-190	24	2	10	0.0	22	5	17	12	5	1.09	Sedikit Boros
2	H-121	17	1	7	1.0	14	2.5	11.5	9.18	2.32	1.21	Sedikit Boros
3	F-221	26	3	5	0.5	10	7.5	2.5	11.92	-9.42	2.60	Sangat Hemat
4	F-881	25	2	3	0.5	43	5	38	10.54	27.46	0.58	Perlu Investigasi
5	F-811	1	1	9	1.0	4	2.5	1.5	0.58	0.92	0.25	Netral
6	F-251	27	1	8	1.0	8	2.5	5.5	15.12	-9.62	3.38	Sangat Hemat
7	H-102	36	2	7	0.0	64	5	59	16.2	42.8	0.56	Perlu Investigasi
8	H-112	36	3	7	0.5	62	7.5	54.5	17.82	36.68	0.58	Perlu Investigasi
9	H-663	27	1	6	1.0	47	2.5	44.5	14.04	30.46	0.57	Perlu Investigasi
10	F-723	14	2	8	0.0	27	5	22	6.53	15.47	0.52	Perlu Investigasi
11	S-25	18	2	4	0.5	7	5	2	7.92	-5.92	2.57	Sangat Hemat

This table shows how fuel consumption is divided into idle fuel (fuel used while stopped), moving fuel (fuel used while moving), as well as the estimated moving fuel that should be used. Fuel Difference is used to determine whether a truck's fuel consumption is in the efficient, wasteful, or Needs Investigation category.

1. IF Fuel Difference ≤ -5 AND Efficiency > optimal value → very economical
2. IF Fuel Difference ≤ 2 AND Efficiency > ½ optimal value → neutral
3. IF Fuel Difference ≤ 5 AND Efficiency > 1/3 optimal value → a little wasteful
4. IF Fuel Difference ≤ 10 AND Efficiency > ¼ optimal value → wastaful
5. IF Fuel Difference ≤ 20 AND Efficiency < ¼ optimal value → very wasteful
6. ELSE → Perlu need investigation

Estimated Operational Cost Savings

Optimization of fuel consumption efficiency using the Deep Q-Network (DQN) method results in a significant reduction in fuel consumption. To see the impact of this optimization more realistically, we conducted a simulation based on the number of delivery trips made by a fleet of 10 trucks.

Table 6. Optimization of operating costs

number of deliveries	Fuel Before (Liter)	Fuel After (Liter, DQN)	fuel savings (Liter)	cost savings (Rp)
3.000	60.000	48.000	12.000	Rp 119.640.000
6.000	120.000	96.000	24.000	Rp 239.280.000
9.000	180.000	144.000	36.000	Rp 358.920.000
12.000	240.000	192.000	48.000	Rp 478.560.000
15.000	300.000	240.000	60.000	Rp 598.200.000

Table 6 s a comparative simulation of fuel consumption before and after optimization using the Deep Q-Network (DQN) model in various delivery scenarios. The values in this table are obtained based on the average fuel consumption per delivery before and after optimization, which is then multiplied by the total number of deliveries.

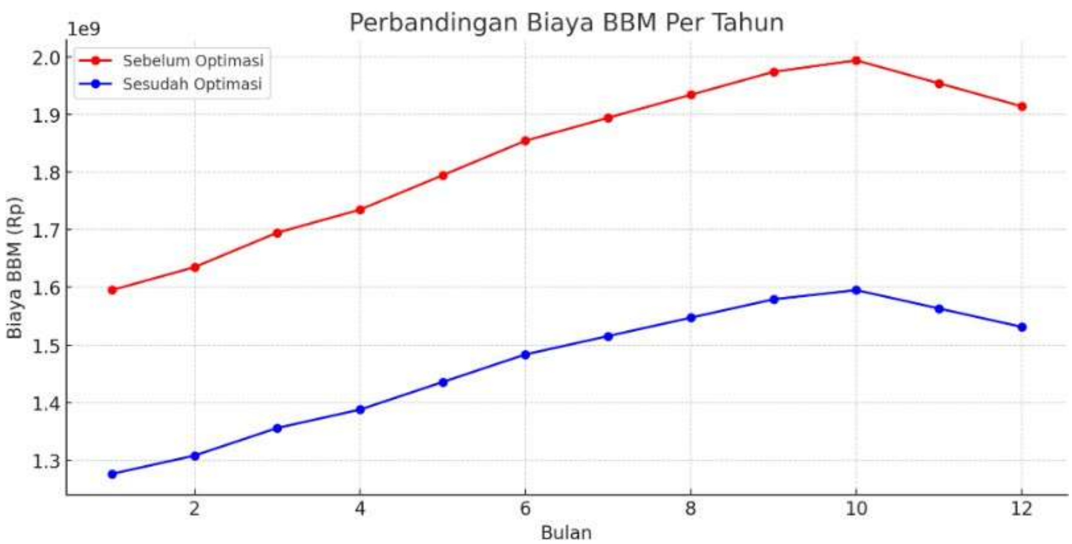


Figure 1. Comparison of fuel costs per year

Figure 3.1 shows the simulated operational cost savings on an annual scale assuming the number of deliveries ranges from 8000 to 10000 times per year. The graph shows that without optimization, the fuel cost increases drastically, whereas after optimization with the DQN method, the cost can be reduced significantly. The lower trend of the blue line compared to the red line clarifies the positive impact of optimization in the long run, allowing the company to allocate the budget to other sectors such as vehicle maintenance or business expansion.

Condition Evaluation

The evaluation of fuel usage conditions in truck vehicles is carried out based on two main parameters, namely fuel difference (difference in fuel used) and efficiency (efficiency of fuel use against mileage). Based on the results of this evaluation, the condition of the vehicle is categorized into several efficiency levels, such as Very Economical, Economical, Neutral, Slightly Wasteful, Wasteful, to Very Wasteful.

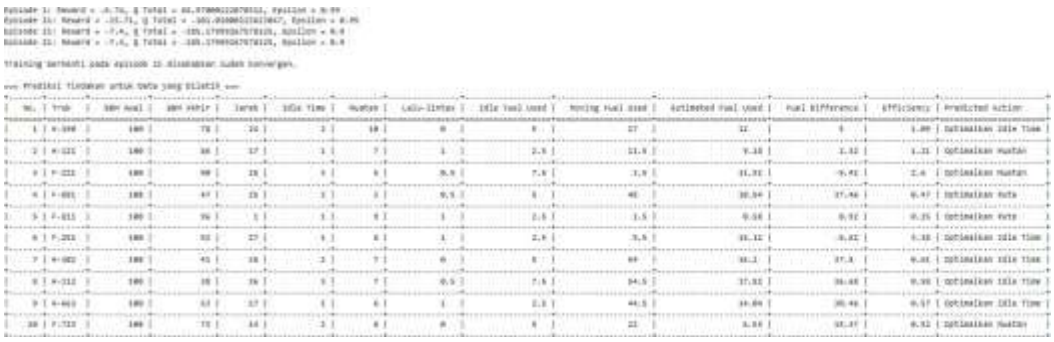


Figure 2. Condition test results

Figure 2 shows the distribution of vehicle conditions based on fuel difference and efficiency. 3 If the fuel difference is negative with a value smaller than - 10 and the efficiency is higher than the optimal efficiency, then the condition is categorized as “Very Efficient”, which indicates that the vehicle is very efficient in using fuel. Conversely, if the fuel difference is greater than 20 and the efficiency is lower than a quarter of the optimal value, then the condition is categorized as “Very Wasteful”, indicating that the vehicle is experiencing excessive fuel consumption.

Using this evaluation method, the company can take precautions against potential fuel misuse and improve the operational efficiency of the vehicle fleet. Regular monitoring of these conditions is essential to ensure that each vehicle is operating at optimal efficiency and avoid losses due to fraud or technical malfunctions in the fuel system.

CONCLUSION

Deep Q-Network (DQN) can be used to assist decision making in fuel budget allocation optimization by utilizing existing historical data. DQN combines Q-learning with artificial neural networks to address complex decision-making problems, such as efficient and optimal budget allocation. The application of DQN in financial decision-making for fuel expenditure has great potential to improve efficiency. However, it requires attention to data quality, appropriate parameter settings, as well as a deep understanding of the external factors that influence decisions.

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