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Optimization of Neural Network Parameters to Increase the Efficiency of Diagnosing Sucker-rod pump Deep-Water Pumping Rod Installations for Oil Production by Dynamometric Methods

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Abstract: This report considered the fine-tuning of neural network parameters for the health conditions of SRD (sucker-rod pump) (deep water pumps rob in oil production). We had a hard time with testing and analysis as we determined the impact of many elements on analytic accuracy and efficiency, e.g., network design, activation functions, learning methods, and regularization methods. These contributing factors to the interrelationships of different types of data will interpret the automation procedure. The factors that will lead to improved performance of the neural networks in SRD water pumping processes are indicated in the findings: the methods, the time of the work is decreased and the machines do everything properly with no pain. Such a discovery can be used in the instruments development that will make oil production even better and reliable.

Keywords: neural network optimization, dynamometric data analysis, SRD system diagnostics, deep-water pumping efficiency, diagnostic accuracy enhancement.

Introduction

A variety of industries such as oil production have shown to that Neural Networks (NN)are successful tools. The employment of magnetometers in the improvement of the sensitivity of the deep-water pumping rod system detection, for example, the SRD system, has a big potential in this matter. NNs can be taught to comprehend such data by using the dynamometric methods which measure force and torque and thereby enhance the effectiveness of medical diagnosis (Al-Rbeawi, 2023).

Neural network parameters optimization is a key element of system improvement of diagnostic capabilities of SRD systems. The neural network might successfully detect the signature of the dynamo wave and abnormalities in the dynamo-metric data by executing adjustments on network parameters like the network design, activation functions, training rates, and normalization technique. This approach identifies design limitation, failures or inefficiency in the pumping equipment. Therefore, maintenance and repairs can be down more smoothly and increase operating efficiency and reduce downtime (Al Toubi, Harrison, & CV, 2023).

Furthermore, apart from fine-tuning several parameters of the NN, there is a need for ongoing refinement and adaptability of the operating conditions and the properties of the data. This stepwise deployment system helps the neural network to be robust and sensitive to any changes of the SRD system. It thus improves diagnostic reliability and performance (Lang et al., 2023).

The attempt of optimizing the feedforward and hidden layer parameters of NNs to detect faults in the SRD installations is one of the cutting-edge efforts entailing bringing up the fields of artificial intelligence and oil production technological devices together, which can transform maintenance paradigms and consequently supply impetus to the process of continuous improvement of the deep-water pumping operations.

Problem statement

The diagnosis of SRD deep-water pumping rod installations for oil production is a challenge due to the fact the systems are rather complex and they are of pivotal importance. Dynamometric skills, which monitor forces and torques per action, make it possible to study not only effectiveness but also how these systems are functioning. In this case, the quality of the diagnosis becomes proportional to the reliability of the data analysis methods.

This problem, however, is rooted in a shortage of valid strategies and approaches for implementing neural networks to assess the dynamometry data properly. The ability of neural networks for assessment of SRD systems is consistently growing, while the ideal settings of their parameters is still mostly a mystery. This gaps leads in the implementation of accurate and effective diagnosis and will ultimately end to poor performance, device downtime and raise the operation costs.

This matter requires a comprehensive knowledge about the NN optimization algorithms used to process dynamometric data in relation to SRD. This research is meant to lead to greater diagnostic accuracy and cost effectiveness by uniquely identifying and optimizing critical features of the network design and learning algorithms, and in so doing, greatly improving dependability and efficiency of deep-marine pumping.

Current research and analysis

Most of the current research on SRD inventions, which is related to the deep-water pumping rods, is presently concerned with the diagnostic accuracy and efficiency schemes, which are partly implemented using the modern data processing techniques, including the neural networks. Researchers are dedicated to the problem of NN optimization, which relates to network designs, activation functions, learning methods and regularization stragies, allowing to data be read extract useful insights (Lang et al., 2023).

Currently SRD diagnostic issues are the focus of research and scientists are investigating different methods which include the anomaly detection, equipment failure prediction and ageing equipment optimization (Azrag, Khatir, Zain, & Odili, 2023). Besides, a growing interest has emerged in integrating several technologically complex devices, such as machine learning, IoT sensors as well as others, to boost diagnostics capabilities even more (Al-Rbeawi, Kumar, Ridha, Ganet, Vasant, and Ilyas, 2020).

Stably, it should be noted that the main research efforts are directed to the development of user-friendly software, as well as systems that facilitate quick application of NN-based diagnostic systems. Academic, technology and product suppliers teaming up brings innovation in this industry which is believed to be a game-changer in the upcoming years in term of how the maintenance will be done and how efficient deep-water pumps oil production are expected to be.

This study will examine and suggest the best ways applying neural networks to dynamic phenomena data to diagnose equipment, namely, SRDs (double-acting plunger) that are used in the production of oil. The paper set about the problem of diagnostics with its accuracy and efficiency enhancement as the parameters for NNs optimization via network design, activation parameters, and learning algorithms. These outcomes of this research work will correspond an outstanding impact on the maintenance of the deep-water platforms, the controlling of downtime, as well as the increase in the operational efficiency of these processes, further resulting in improvements in the oil production business.

Research Result

In line with the investigation aiming at NN variables for deep-water oil production pumping rod installations for SRD, it was found that remarkable results were obtained. The number of significant discoveries that have resulted from extensive testing and evaluation has shown that many NN optimization strategies are helpful in increasing diagnostic accuracy, or in how well they can link symptoms to diseases (Liu et al., 2023).

The first one of our network analysis is that deeper architecture with several hidden layers could capture more detail in the signal from dynamometry where our results have represented a higher accuracy. Yet, a perfect NN design may be achieved or not if the SRD framework is not complex enough and/or data properties do not meet this requirement (Al Toubi et al., 2023).

Besides this the desity selection of the proper numpy of the activation functions will have a big impact on the NN's capability to imitate of non-linear correlations from the dynamometric data. Such functions like ReLU (Rectified Linear Unit) and sigmoid are well known for their high performance when it comes to the difficult area of recognizing the diverse dynamics of SRD activities (Soroush et al., 2022).

Apart from this, SGD (Stochastic Gradient Descent) and Adam are the methods that are used to enhance the training speed of neural networks. Also, these techniques have improved the generalisation ability of the neural networks. The researchers could repeatedly adjust parameters of learning rate and momentum which in turn helped them to have faster learning processes and better testing results for different datasets.

On the other hand, the found that well-known regularization methods like dropout and L2 regularization really help to reduce the overfitting and enhance the generalization capability of NN (Soroush et al., 2022).

Unlike traditional neural networks these methods do not require model memorization but at the same time increase the network's ability of generalization to unknown data promotes their utilization in diagnostic system in real-world environments. In short, the research findings reveal that the two should be so maneuvered artfully that getting SRD rod installation in deep-water pumping can be better maintained and efficient in the oil and gas sector (Nnabuife).

Conclusion

Furthermore, the research results underscore the importance of better coefficients for principal line contours to distinguish formation heights and locate deep-water pumping rod into oil wells. The current study made a series of breakthroughs such as network architecture, neural excitation function, learning algorithm, and regularization method. The use of complex analytical data processing methods, for example, using neural networks, in the maintenance processes, decrease of downtime and optimizing of the operations in deep-water pumping will be much easier and reliability to be brought about. These studies give great importance to the continued research and improvement of this industry, along with which the establishment of new processes in oil production could be possible.

References

Al-Rbeawi, S. Upstream Oil and Gas Technology.

Al-Rbeawi, S. (2023). A review of modern approaches of digitalization in oil and gas industry. *Upstream Oil and Gas Technology, 11*, 100098.

Al Toubi, S., Harrison, D., & CV, S. (2023). Evaluating and predicting overall equipment effectiveness for deep water disposal pump using ANNGA analysis approach/Soud Al-Toubi, Babakalli Alkali, David Harrison and Sudhir CV. *Journal of Mechanical Engineering (JMechE), 20*(2), 199-225.

Azrag, M. A. K., Khatir, S. K., Zain, J. M., & Odili, J. B. (2023). *Predictive Maintenance of Produced Water Re-injection Pump Failure in the Field of Oil and Gas: A Review.* Paper presented at the 2023 International Conference on the Cognitive Computing and Complex Data (ICCD).

Kumar, A., Ridha, S., Ganet, T., Vasant, P., & Ilyas, S. U. (2020). Machine learning methods for herschel–bulkley fluids in annulus: Pressure drop predictions and algorithm performance evaluation. *Applied Sciences, 10*(7), 2588.

Lang, K., Yin, Z., Chen, Y., Li, Y., Li, Z., & Tian, D. (2023). *Discrimination of Deepwater Drilling Overflow Based on EDF-FM Model.* Paper presented at the 2023 8th IEEE International Conference on Network Intelligence and Digital Content (IC-NIDC).

Liu, X., Jia, W., Li, Z., Wang, C., Guan, F., Chen, K., & Jia, L. (2023). Prediction of Lost Circulation in Southwest Chinese Oil Fields Applying Improved WOA-BiLSTM. *Processes, 11*(9), 2763.

Nnabuife, G. S. New multiphase flow measurements for slug control.

Soroush, M., Mohammadtabar, M., Roostaei, M., Hosseini, S. A., Fattahpour, V., Mahmoudi, M., . . . Cheng, L. (2022). *Downhole Monitoring Using Distributed Acoustic Sensing: Fundamentals and Two Decades Deployment in Oil and Gas Industries.* Paper presented at the SPE EOR Conference at Oil and Gas West Asia.