

English Extended Abstract

An Overview of the Application of Machine Learning in Solving Drilling Problems

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Received: 1 January 2024; Accepted: 6 April 2024

DOI: 10.22107/jpg.2024.421270.1222

Keywords**Drilling problems, Pipe stick, Circulation loss, Fractures, Kick, Machine learning.****Abstract**

The high cost of drilling operations has led to increasing challenges in optimizing drilling operations. The key to success in reducing these costs is designing the well program based on the prediction of potential drilling issues and problems. Over the past few decades, the drilling industry has shown an increasing interest in machine learning to predict drilling problems. This paper presents a comprehensive review of studies related to the application of machine learning in predicting drilling hazard events. In each study, machine learning algorithms, the number of data points, input and output parameters to the machine and the performance of the corresponding algorithm are extracted from previous studies. In addition, limitations, similarities of the studies in each category are summarized and a review of the literature is provided along with recommendations for the development of future studies. These reviews show that the artificial neural network algorithm is the most popular method among the machine learning algorithms in the studies; Meanwhile, other algorithms such as support vector machine algorithm and random forest may show better performance in extracting results. It should also be noted that many of the intelligent models presented by researchers are based on limited samples and the specific conditions and may not be generalizable.

1. Introduction

Failure to control and prevent the occurrence of drilling problems leads to other problems such as financial losses, time loss, and loss of human ability. The key to achieving ideal, safe, and economical drilling is designing appropriate drilling programs based on predicting possible well problems [1]. Among the most common drilling problems are the drill pipe sticking [2], loss of circulation [3], hole deviation [4], casing collapse [5], drill pipe failures [6], borehole instability [7], producing formation damage [8] and personal- related problems [9]. It is very important to understand all these problems, the causes of each of them, their prediction, and achieve the goal of the target area.

The value of knowledge and machine learning techniques have been widely recognized in

various applications, while their potential in the oil and gas industry has not been fully and practically utilized [10]. Traditional data preparation and analysis methods are not able to quickly extract information and visualize large complex data sets, so machine learning methods are used to solve engineering problems with the ability to consider all effective parameters simultaneously [11]. This study gives an overview of the main principles of machine learning in the drilling industry and discusses drilling problems.

2. Methodology

In this study, since the aim is to review several drilling problems and investigate the studies conducted on the application of machine learning methods to these mentioned problems, these problems and studies are briefly introduced in the

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following.

2.1 Pipe sticking

In drilling operations, pipe sticking is considered unable to move easily and get out of the well without damaging the pipe and increasing the drilling rig's maximum hook load. There are two types of pipe sticking mechanisms: differential pressure pipe sticking and mechanical pipe sticking. Differential pressure pipe sticking occurs in unbalanced drilling. A part of the drill string is placed in a mud cake that is formed on the wall of the permeable formation during the drilling process. If the mud pressure acting on the outer wall of the pipe is greater than the formation fluid pressure, the pipe will be differentially stuck in the well [12]. Mechanical pipe sticking occurs mostly in shale formations. Depending on the composition of the mud and the weight of the mud, shale can move into the well in a skin or plastic form and cause the mechanical pipe sticking. [13]. Using machine learning methods to predict this complication is important and helps to reduce the occurrence of other drilling hazards. According to previous studies, the parameters of pressure difference, depth, rate of penetration, plastic viscosity, yield point, gel strength, and length of bottom hole assembly are the most effective for predicting pipe jamming. Therefore, choosing the accurate values for these parameters is very important in preventing the drilling pipe from getting stuck [14,15].

2.2 Loss of circulation

Fluid loss is defined as the complete uncontrolled mud flow into the formation, which is sometimes known as the thief zone [16]. In this regard, research has been conducted to prevent fluid loss from happening or to detect the possibility of it happening by relying on machine learning methods. Based on studies, Depth, pressure parameters (for instance, standpipe, casing, and pump pressure), pump flow rate, lithology, mud weight, solid percentage, mud viscosity, yield point, gel strength, and weight on the bit were the most parameters in the studies. They have been used as model input to estimate the amount of lost circulation [16,17].

2.3 Fracture

Fracture occurs when the drilling fluid pressure exceeds the fracture pressure of the formation. As a result of high mud weight and as a result of closing a well at high pressure can also lead to fracturing [18]. The most important parameters that have been used in most studies for

machine learning model development include seismic data, well logging data (sonic, diameter, resistance, porosity, and density), and lithology [19,20].

2.4 Kick

Kicking can be caused by several factors related to hydrostatic pressure (e.g., abnormal borehole pressure, drilling fluid loss) or pressure control equipment for drilling. Kick is a dangerous incident that is directly affected by the use of incorrect density of drilling fluid [21]. It can be found from the research related to the use of machine learning to predict the kick, that key parameters in kick detection include pressure parameters (such as standpipe pressure, and casing pressure), mud weight, flow rate, hook load, rate of penetration, weight on bit and depth [22,23].

3. Results and Conclusions

According to the mentioned research, a relative classification of the extent of their use of various algorithms for modeling and predicting drilling problems has been extracted over the past years. Fig. 1 to 5 show the extent of researchers' use of various techniques in this regard during the last decade. As it is obvious in the figures, the popularity of artificial neural network, relative to other algorithms, among studies has remained stable for many years, and the relative use of decision tree algorithm by researchers (between 2010-2023) has accelerated. Bayesian networks have been evident for a long time, but since 2010, researchers have increased the use of this algorithm. The use of the support vector machine algorithm began among researchers in 2002 and has continued until now; In such a way that the amount of use of this algorithm has reached its maximum in 2023. On the other hand, the number of researchers using the linear regression algorithm has decreased compared to previous years. The reason for this can refer to the weak performance of this method compared to other machine learning methods.

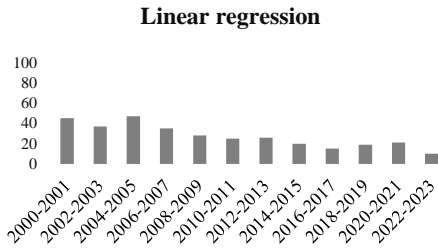


Fig. 1. Schematic of using the linear regression algorithm in the last decade.

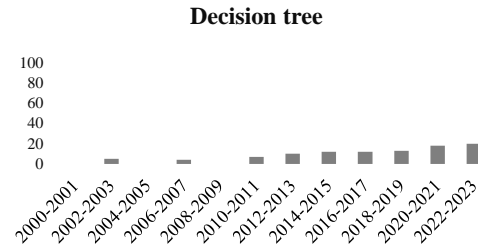


Fig. 5. Schematic of the process of using the decision tree algorithm in the last decade.

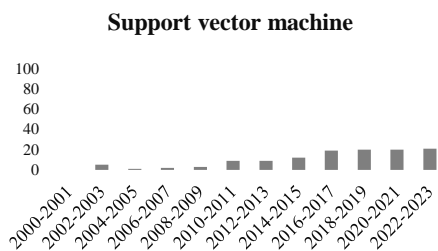


Fig. 2. Schematic of using the support vector machine algorithm in the last decade.

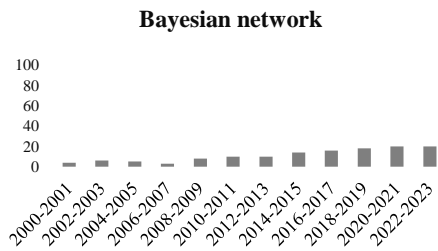


Fig. 3. Schematic of using the Bayesian algorithm in the last decade.

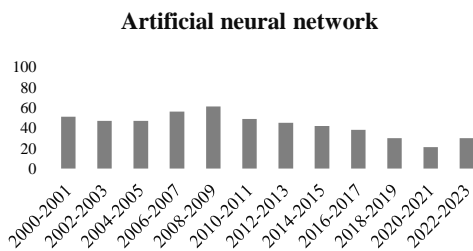


Fig. 4. Schematic of using the artificial neural network algorithm in the last decade.

The results obtained in this research are based on a detailed investigation of the drilling pipe sticking, loss of mud circulation system, fracture, and kick. The following are summarized from the results of the studies.

1. It seems that the performance of the artificial neural network can be increased under the influence of the optimization algorithm. The artificial neural network is a widely used algorithm in forecasting drilling problems. According to studies, the performance of this algorithm increases significantly when combined with the genetic algorithm.
2. By comparing the results of the studies, it can be seen that the support vector machine and random forest algorithms perform better than the artificial neural network in the same studies.
3. The most effective parameters are presented in each section of the investigation of the use of intelligent models in predicting drilling problems.
4. Many intelligent models are designed using limited samples and for specific types of formations and regions. Also, not all parameters affecting the target have been used for modeling. Therefore, the results of such studies may not be generalizable.
5. To increase the performance of machine learning algorithms, it is recommended to remove outlier data and choose the best parameters of the algorithm.

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