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Data Driven and AI Methods to Enhance Collaborative Well Planning and Drilling Risk Prediction

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Abstract

ADNOC is continuously enhancing its capabilities to manage its oil and fields efficiently by better planning, execution and operations that drives field development decisions, well performance, and safe operations. In this regard, ADNOC envisages to leverage the evolving Oil and Gas 4.0 technologies to enhance the well planning decisions of the sub-surface and drilling team through data-driven and AI methods.

Effective well planning and operations require collaboration between different subsurface teams and drilling team leveraging multidisciplinary data, historical events and risks and constructing integrated drilling and sub-surface model for collaborative planning and keeping the model live. This requires having a live sub-surface model that is kept close to the field reality while reducing uncertainties. However, extracting key learnings, knowledge and experience from a variety of sources and reports is intense and requires lot of manual processing of data.

An AI-based solution leveraging data analytics, natural language processing and machine learning algorithms is developed to automatically extract knowledge from a variety of data sources and unstructured data in building a live intelligent model that enables effective well planning, predicting operational hazards and plan mitigation. The solution systematically extracts, collects, validates, integrates, and processes a variety of data in different formats such as well trajectory, completion, historical events, risk offset well information, petrophysical data, geo-mechanical data, and technical reports. Newly acquired data comprising drilling events, geological and reservoir properties are integrated continuously to keep the model live and digital representation.

Introduction

ADNOC as part of its research and technology development initiatives has been working towards capitalizing the technology advancements of the 4th industrial revolution (big data analytics, machine learning, AI). The objective is to transform the traditional upstream workflows and modelling techniques

by automating the routine engineers' tasks to reduce the cycle time of engineering workflows and decisions. Such initiatives require strategic partnership with research establishments and service providers having advancement in relevant domain and technology

For the Intelligent Integrated Sub-Surface Modelling program, ADNOC has forged a strategic partnership with Schlumberger to apply artificial intelligence and automation solutions that shall transform the traditional end to end reservoir management workflows. The intent is to move from the industry's current traditional, highly time-consuming and manual driven reservoir management approach to one that is highly automated, uses analytics and AI to inform and orchestrate all components of the modeling and management workflow.

In order to be able to deliver on this ambition, a single environment is needed that can enable the direct integration, analysis and modeling of all the different domain disciplines. This is one environment where domain silos are broken down and insights can be found due to the integration and liberation of data and ideas across all the different domains and contributors.

A system is planned where drilling, fluids, production, geophysics, geoscience and reservoir engineering data all reside, and can all be integrated to identify the challenges and find solutions to the challenge of optimizing the value and sustainability of the resource. This environment allows machine learning to be applied across all data and modeling workflows. This, coupled with the ability to automate traditional physics driven engines, allows us to move rapidly to a data-driven world that can respond faster, with greater confidence, accuracy and sustainability to field development planning and reservoir management challenges.

The Intelligent Integrated Subsurface Modelling (IISM) program is aimed at delivering a step change in capability, insight, speed, accuracy, risk understanding and mitigation across the entire reservoir management workflow. The proposed system enables liberating Petro-technical experts to focus on the key decisions and questions, identify the critical business goals and outcomes and ensure all reservoir concepts are continuously challenged and reviewed. All while continuously ensuring quality at all steps of the process.

We believe that by liberating data, integrating workflows and utilizing the latest available digital technologies, the IISM can drive a far more sustainable and effective reservoir & drilling management system that will benefit the oil industry. We believe the time is now to embrace these challenges, make the changes and drive solutions for the future.

ADNOC group of companies drilled thousands of wells on multiple fields with a mix of drilling complexity over the last 60 years, Drilling a large number of wells generates a large amount of data during the drilling and completion activities. Until 2000, the drilling data were captured in unstructured form and since 2000 most of the drilling operational data started getting captured in a structured way with a set of documents, spreadsheets and reports for each well containing various types of data sets.

Historically, the drilling engineer required spending a lot of time to run offset well analysis to find the risks and events that happened in the past. This process was considered a manual process and it require huge effort to identify the right data source. This manual effort always leads to inaccuracy of the knowledge extraction and leave a lot of data untouched due to the huge amount of data available. These captured data will be stored in Excel format, which is not being updated with new wells drilled on each field.

The novel approach of IISM drilling intelligence is transforming the process of the knowledge extraction and prediction using modern data analytics, natural languages processing (NLP), and machine learning (ML) workflows to automate the entire the process where the data will be captured and visualized along with the subsurface context to maximize the value from the extracted data. The solution developed utilizes advanced NLP technology coupled with Monte Carlo simulation techniques to achieve the results. NLP techniques provide automatic fine-tuning on the new dataset once it is obtained to enhance the output. The solutions are designed to ingest various types of datasets using customized python scripts. The solution has the capability to connect to existing drilling databases to leverage the big data analytics.

The AI-based intelligent solution provides an opportunity to radically improve the collaborative well planning process, select reservoir targets, and enable delivery of quality wells. The solution provides geoscientists and engineers to rapidly identify patterns, hazardous zones, and sweet spots for effective well planning and execution, including GeoSteering operations. The solution enables plans to be continuously improved using new information from newly drilled wells, and future programs can learn from prior experiences. Consequently, the solution enables learning potential in every event, near miss, or success in every well that is drilled. The integrated visualization environment enables seamless visualization of the subsurface data along with events and risks, patterns, and trends.

The above is achieved through innovative AI-based advanced workflows and a unique combination of ML and NLP techniques to better understand geological and operational hazard in a fully integrated workflow that can optimize efficiency, safety, and performance and drive effective field development planning and operations.

This paper is organized as follows. First, a description of the developed solution workflow is provided. Second, the validation of the NLP model and risk prediction is discussed. Third, data and results are presented to illustrate the value of the solution. Conclusions follow.

Description and Application of Processes

The solution is designed and developed in a modular way and consists of different components as described in Figure 1. The solution is built on a robust petrotechnical platform that comprise of advance data foundation, analytical processing and machine learning engines, petrotechnical modules and visualization foundation. Below, we briefly describe the different functionalities in the developed application.

- **Data loading and cleaning**: This component includes the following:
  - Data auditing and cleaning of the input data coming from the offset wells drilling and subsurface database
  - Data ingestion in .csv and Excel format for both time series and drilling data using a unique set of data loaders in automated methods
  - Data QC check of the ingested data, NLP model, and risk prediction accuracy
- **NLP extraction process**: In this component, we implement the NLP techniques to perform the following tasks
  - Extract the learning of risks and events from DDR remarks & BHA run reports
  - Visualize the extracted learning of risks and events along with other input datasets
- **Time series analysis**: Here, we provide deeper analysis of the available data by
  - Analyzing time series data for optimal operation parameters to achieve highest ROP per formation or a depth range
  - Analyzing the relationship between time series data and DDR events in order come up with best parameters to avoid operational risks and events.
- **Clustering** (study area and learning project): To capture information through trends,
  - Users can select a certain area on a selected field to run a study on the past risks and events with certain duration
  - Based on the selected field area, the solution will filter the historical events and risks
- **Events and risks prediction**: Using the ingested data, an ML model is created

- Using MC simulation, the solution will predict the risks and events for a 10-well incremental campaign for future wells drilling on selected area

- **Data export and visualization:** A component rich with visualization features is developed to provide more flexibility in drawing insights from the drilling risk analysis process
  - Results represented in a set of .csv & .XML files.
  - The result shall be visualized in Petrel along with the other subsurface context and Spotfire tool.

Figure 1—Drilling Intelligence - Risk Prediction Solution workflow

Below sections present more in details the NLP process and the accuracy of the extracted data.

NLP model and Risk Prediction Validation

A set of 66 wells was selected in the candidate field to demonstrate the capabilities of the developed solution. The knowledge extraction validation is performed by manually extracting the knowledge by a subject matter expert, and then, through a confusion matrix concept (Figure 2), checking the accuracy of the automatic risk vs manual risk extraction. After few iterations, the model developed was accurate at 97.45%. For the risk prediction, the model was validated based on the historical wells along with the newly drilled wells in the same area to indicate the accuracy of the prediction risks and events as shown in Figure 3.

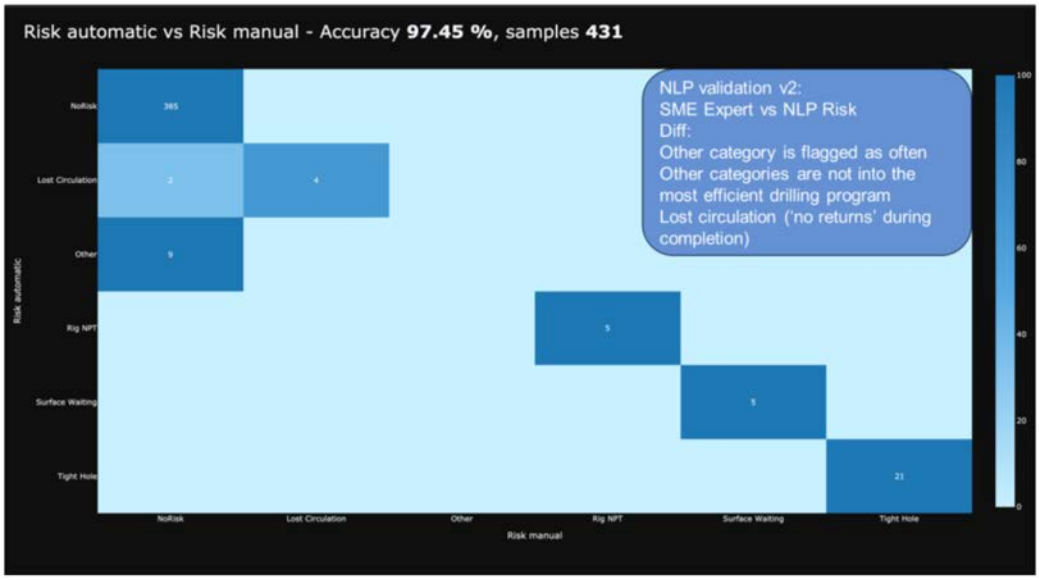

Figure 2—NLP validation using confusion matrix

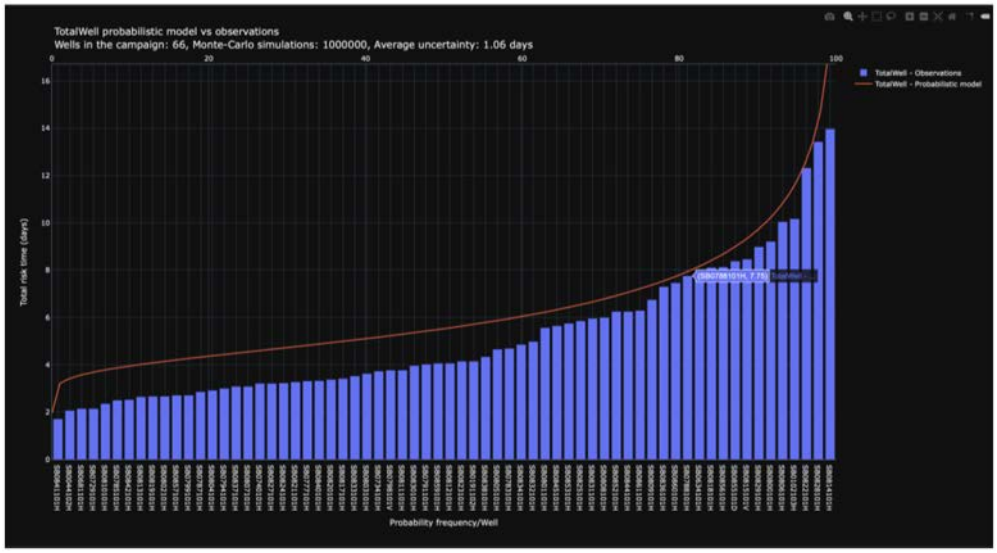

Figure 3—Prediction model validation over historical wells duration

Solution functionality description

The drilling risk extraction consist of several functionality described below:

Data cleaning & ingestion, this feature provided the ability to review the data prior prior to the ingestion process, along with the data ingestion the process of NLP knowledge extraction is happening in the back ground.

Input data visualization, once the data ingestion is completed, the end users will be able to visualize the input data coming from the drilling data base along with subsurface information such as DDR remarks, activity duration, activity depth, actual survey, formation maker, BHA details, casing details etc. in different ways such as map display, TvD chart, relative TvD chart, 3D field display, 3D field with formation tops etc.

Extracted knowledge and prediction analysis, the extracted knowledge by applying the NLP process can be analyze in different ways such as risk per depth, risk per formation, risk per section, risk bubbles distribution in time vs depth chart and risk at bit depth. The risk prediction for the future wells planned to be drilled on a selected area to allow the drilling engineer to better understand the risk distribution on the selected area, this risk prediction analysis can be visualize using Risk Pie, Risk per section and Risk per formation.

Time series data analysis, along with the input data coming from the drilling remarks written by the rig site supervisor, the solution provides the capabilities to analysis the time series data to have a better understanding of the optimum drilling parameter per depth range or formation tops to achieve the optimum ROP using spider plot display.

New learning area analysis, this feature helps the engineer to have their own analysis on a selected area of the field with a filter of the dates of wells operation.

Data export, this feature enables the engineer to export the input and extracted data to be used and visualized in the other integrated platform Petrel and Spotfire.

Data visualization in Spotfire & Petrel, the ultimate goal of data visualization in Petrel platform is to display the extract risk along with the subsurface context in 3D windows and well section window along with the results generated by the other IISM tools. Additionally, the engineer will be able to display the data in Spotfire application with similar set of displays available in the solution to maximize the usage of the output results of the risk extracted.

Presentation of Data and Results

In this section, we provide details on the data and results obtained. IISM drilling solution has devised a data architecture that stores the harmonized data from different drilling repositories into analytics-ready formats and applies statistical techniques to get meaningful insight out of large data. An analytical visualization gives statistical insight into a human-comprehendible format out of a large ensemble of historical data. Tested data architecture is scalable to store reasonable smaller samples into spreadsheet file-based storage to protype the analytical KPI based on operational highlights and rapidly scale that up into large enterprise deployment like cloud-based architecture, which is a success factor for ADNOC.

A performant application programming interface (API) is developed to test, harmonize, and ingest ADNOC source data stores and prepare for statistical analysis. The ingestion pipeline will be leveraged to rapidly ingest large amounts of operational data from structured and unstructured data sources from a diverse and complex inhouse data environment. The NLP mechanism used a large ensemble of text data to find hidden trends, coupled with a statistical algorithm like Monte Carlo simulation to predict risk probability based on historical risks encountered in different formations and well sections. Finally, the historical and predicted data are correlated to gain confidence factor.

Final risk calculation is plotted in diverse analytical visualization platforms. Opensource and proprietary analytics dashboards and subsurface visualization platforms are tuned as per ADNOC operational needs based on recommendations from subject matter experts. The agility of the approach demonstrates operational flexibility and responsiveness of the tool and rapid scale-up capability for the enterprise cloud platform.

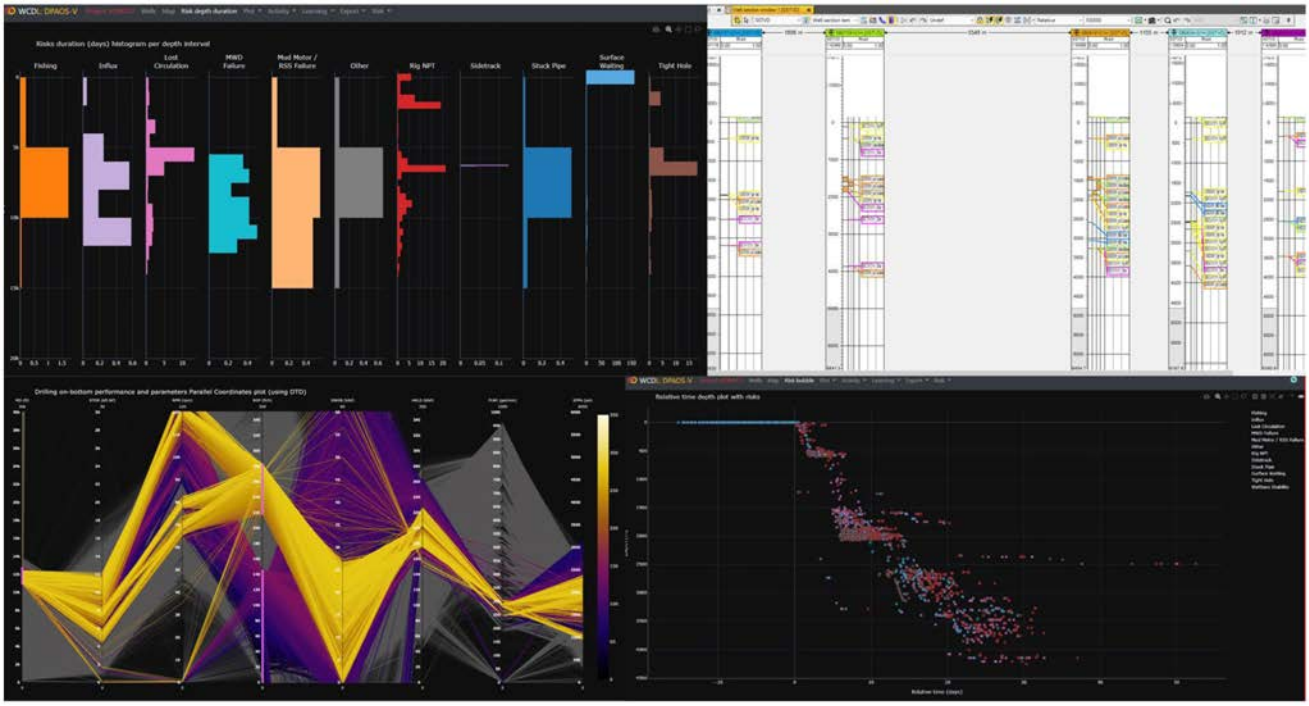

Figure 4—Statistical risk visualization on various analytical sub-surface application platforms

Conclusion

This paper presents the use of artificial intelligence to systematically extract and predict drilling risks and events with high accuracy. This eventually will help to improve the awareness of the historical risks and events for effective well planning, mitigation of the operational hazards and will improvement of the drilling

parameter section to achieve the optimum ROP for each formation. Going forward the application will adapt additional data-driven approaches for risk prediction and operation improvements.

Way forward

In the coming phases, the solution would be further enhanced to bring the sub-surface context by ingesting operational geology reports, end of well report, and well log information and other sub-surface information. The visualization environment shall be enhanced to include 3D visualization to present the drilling knowledge and risk in a sub-surface context that shall enable collaborative analysis and decisions.

NLP based search functionality, shall be incorporated that shall enable the engineers to rapidly look for potential events, risks and combined sub-surface parameters in a map and 3D.

Finally, the module shall be integrated to the overall Integrated Sub-Surface Model to support integrated well planning and sub-surface decision making process while augmenting to realize the full value of the integrated IISM solution.

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Nomenclature

IISM	Integrated Intelligent Subsurface Modelling
MC	Monte Carlo simulation
NLP	Natural Language Processing
ML	Machine Learning
AI	Artificial Intelligence
KPIs	Key Performance Indicators
ILT	Invisible Lost Time
NPT	Non-Productive Time
API	Application Programming Interface
DDR	Daily Drilling Report
QC	Quality Check
BHA	Bottom Hole Assembly

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