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Please fill in your manuscript title.	A Hybrid Machine-Learning/User-Assisted Workflow for Locating Collars on Multiple Nested Tubulars

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Abstract

1. Objectives/Scope

Identification of pipe collars in well pipes is vital for oil and gas well management, which can provide critical information for pipe integrity analysis and pipe maintenance. A multifrequency electromagnetic pipe inspection tool with multiple transmitter and receiver arrays was designed to detect anomalies on each of the individual wall thicknesses of multiple nested pipes. Identifying collars on multiple pipe strings from electromagnetic log data acquired from this tool remains a challenging problem because of the ambiguous collar signature due to the overlapping collars on different pipes. Thus, it is almost impossible to design a fully automated collar locator that could make accurate estimation of collar locations on all pipes. In this paper, we propose an interactive workflow in which an automatic algorithm is combined with a user-assisted methodology for resolving ambiguities. A multi-class machine-learning model is trained to guide user decisions by computing the likelihood of a feature being a collar on any given pipe string.

2. Methods, Procedures, and Process

A hybrid workflow combining machine learning and user-assisted decisions is designed to efficiently identify the locations of collars on each individual pipe – up to five pipes. The algorithm starts with the user specifying the location of at least one representative collar on each pipe, whose signatures are used as reference. The locations of the remaining collars are estimated using a pattern recognition approach by matching the signature of the user specified collars. Whenever the algorithm fails to uniquely identify a collar location, user is prompted to decide the location based on machine-learning-estimated likelihood curves and collar periodicity, and the algorithm continues till it pauses at the later depth with ambiguity or completes identifying the location of all the collars.

3. Results, Observations, Conclusions

A 15,000 ft log from a well with four pipes has been tested. The algorithm prompts for the user input at ten or fewer locations on average. When compared with manually picked collars, the average error in the location of collars is less than 0.5 ft, which is good enough for most practical applications. The total running time of the entire algorithm is much less than previous methods or doing by hand. The results reveal that this approach can improve the accuracy over an approach based purely pattern recognition, it saves much time for an analyst to inspect algorithm picks and correct errors.

4. Novel/Additive Information

The techniques presented can accurately and efficiently locate the collars on all the pipes of a multi-pipe configuration. The assessment of the integrity of the different pipes in the configuration would benefit from the identification of the position of the collars. It also benefits the engineers in oilfield to make accurate decisions on wellbore maintenance.

Keywords

Collar identification; electromagnetic corrosion detection; well integrity; machine-learning; user-assisted decisions.