Summar

Core plugs and the associated thin sections provide high quality "ground truth" measurements of porosity, permeability, and grain density.

This work presents an artificial intelligence (AI) / machine learning (ML) workflow that uses well gamma ray logs, and textures derived from core photographs to upscale permeability measurements over the length of the core.

The "Upscaling" Problem: Convert point-wise plug measurements into high resolution continuous curves, comparable with other well log and core data

The Objective: Predict permeability along the entire core using AI / ML

An important preprocessing step was to use an unsupervised learning method to first discriminate facies based on the core photos. The data used for training showed an imbalance in the relative sampling of plugs from each facies type. We address this imbalance by adding an importance weight in the regression problem. The results show a faithful reconstruction of permeability compared to measurements made with a profile permeability tool.

Introduction

- Reliable, densely-populated permeability measurements in a well are notoriously difficult to acquire cost effectively.
- Al / ML hold promise to address this because of the ability to quickly train, update, and predict permeability with a sparse number of input points.
- Other ML approaches to this problem often try to estimate permeability from porosity [1]
- We propose an ML application to estimate permeability along core using core plugs, gamma ray measurements, and plug permeability measurements



The core data comes from Poseidon in the Browse Basin of Western Australia [2]. Input data are photo and UV core images, core plugs with permeability measured and profile permeability (for validation of results), and gamma ray measurements along the core.

Conclusion

Permeability prediction matches the verification profile-permeability measurements except in places of low-permeability, extremely thin layers (a symptom of scale)

ENTHOUGHT

PERMEABILITY PREDICTION USING MACHINE LEARNING TO UPSCALE CORE MEASUREMENTS

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We'd like rock type to inform porosity, but to do so, we need a classification scheme to identify it. Using unsupervised ML, we cluster to determine the rock type of each plug using features derived from the core photographs.

Measures of the texture of 8 patches taken around the plug location are analyzed and used for determining rock type. Specifically the image attributes used are the Haralick features: contrast, correlation, average, variance, entropy, etc. [3]

Proposed Method

Features to train the regressor:

- Plug permeability measurements
- Core gamma value (both point value and bedding level)
- Texture features around the plug location

This rock type along with plug permeability, gamma ray value, and features of high resolution core photographs are used to make a densely populated model of permeability using supervised machine learning (specifically the random forest algorithm). Since the number of samples in each class isn't equal, we include a sample weight to mitigate bias in the results.

References

[1] Ahmadi M. A., and Z. Chen, 2018, Comparison of machine learning methods for estimating permeability and porosity of oil reservoirs via petro-physical logs. Petroleum [2] Poseidon data courtesy of Geoscience Australia. Creative Commons "Attribution 3.0 Australia" license

[3] Haralick, R. M., I. H. Dinstein and K. Shanmugam, K., 1973, Textural features for image classification. IEEE Transactions On Systems Man And Cybernetics

Data Analytics Study Group

Methodology

 Rock type according to clustering result Sample weight inversely proportional to the

rock-type population

Unsupervised Learning (Preprocessing)

Supervised Learning (Modeling) & Verification

Data Science Convention April 04, 2019 Norris Confrence Center, CityCenter Houston

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Classification gives the rock-type requirement for training in a geologically meaningful way

96 Plugs Used. RMSE: 1.172

71 Plugs Used. RMSE: 1.026

Depth [m

