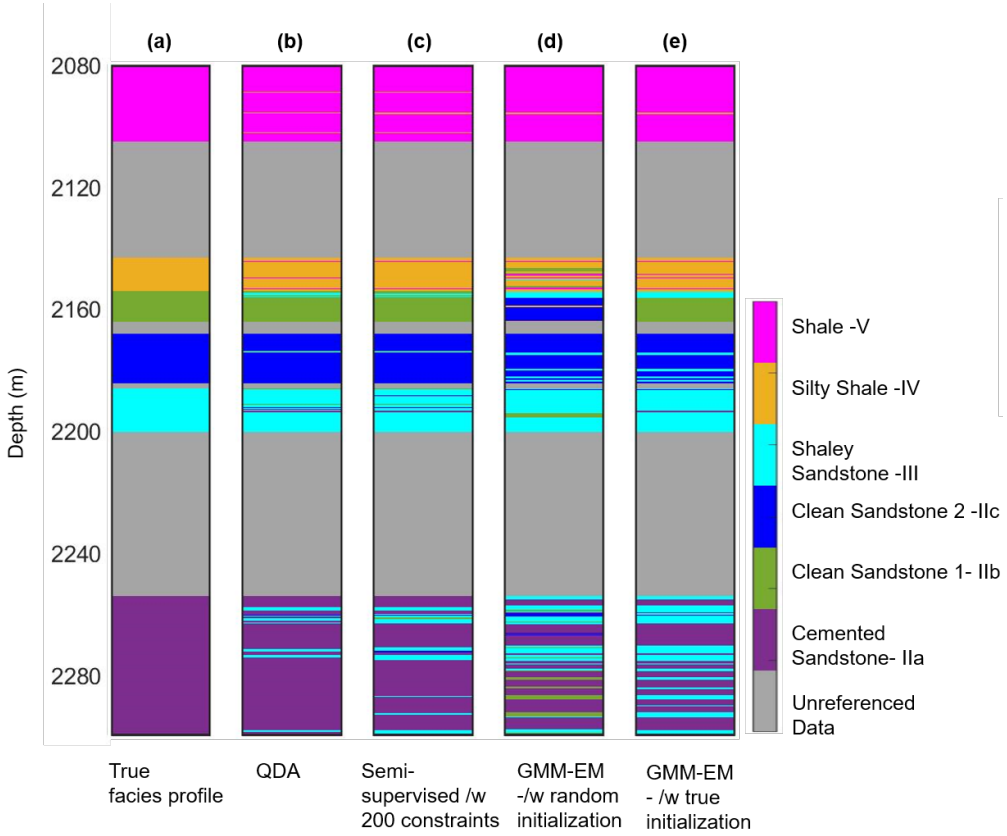
WELL-LOG FACIES CLASSIFICATION USING SEMI-SUPERVISED ALGORITHM

Wei Xie and Kyle T. Spikes

Department of Geological Sciences
The University of Texas at Austin

ABSTRACT

We present a technique for well-log facies classification using a semi-supervised algorithm. This method incorporates guidance from domain experts. It considers both the desire of domain experts and the distribution characteristics of well-log properties. The semi-supervised algorithm aims to obtain well-log facies that are more geologically and seismically meaningful than the conventional methods. We impose guidance from a user as pairwise constraints, where must-link specifies pairs data that need to be assigned into same group and cannot-link indicates that pairs data should be classified into different groups. To maximize the efficiency of constraints, we adopt a min-max criterion to actively query constraints based on data uncertainty. We incorporate the acquired constraints into facies classification in two ways: modification of the objective function and optimization of classification subspace. Penalizing violations of the constraints encourages satisfaction of user supervision. Use of metric learning helps find the optimal subspace, where data has better discrimination. An iterative expectation-maximization (EM) algorithm is utilized to minimize the objective function. Using the proposed method, we classified lithofacies based on a set of well logs from Glitne field, North Sea, where six lithofacies had been defined initially. We presented a comparison among semi-supervised method, quadratic determinant analysis and expectation-maximization with a Gaussian mixture model algorithm. Classification results illustrated that facies using the semi-supervised approach achieved good matches with true labels. As we used more constraints, the success rates of semi-supervised classification improved, and we observed that 200 constraints were sufficient to achieve good facies classification. We also tested a scenario with five facies, where we combined silty shale and shale into one group due to severe overlap in the elastic domain. Results demonstrated that the semi-supervised approach produced facies that were more consistent with expert intention, and they were more geologically interpretable. The techniques and results illustrated here could be performed in any type of reservoir facies classification, and the semi-supervised algorithm classified facies honors the desire of the user and data characteristics.



Most likely facies assigned using different methods with six facies. From left to right: (a) true facies profile for reference. (b) quadratic discriminant analysis (QDA) results. (c) semi-supervised results. (d) expectation-maximization with Gaussian mixture model (GMM-EM) results with random initialization. (e) GMM-EM result with true initialization. Colors in facies profiles represent cemented sandstone in purple, clean sandstone 1 in green, clean sandstone 2 in blue, shaley sandstone in cyan, silty shale in orange and shale in magenta. QDA and semi-supervised algorithms outperform GMM-EM algorithms significantly.