Prediction of FBHP using advanced data analytics

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Research team

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Problem definition and aim

Flowing bottom-hole pressure (FBHP) is a key metric for optimising coal seam gas well performance and enhancement of production. Downhole pressure gauges are increasingly being used to measure the FBHP. However, they are impractical, expensive, and complex to install and maintain. Consequently, reliable measurement and prediction of FBHP, required to forecast well production, remains a challenge.

This project aims to predict the FBHP in coal seam gas (CSG) wells by taking advantage of the subsurface and surface data and advanced analytics.

Data description

Key variables: FBHP, pump torque, pump speed, gas flow rate, tubing water rate, separator water rate, casing pressure and tubing pressure

Number of wells: 5 wells from two different fields

Production time: 15-18 months

Sampling rate: 1 minute

Methodology

Linear regression and neural networks were used in developing predictive models. Ordinary least square (OLS), LASSO, Ridge and Elastic Net linear regression models were considered both with and without pairwise interactions between the predictor variables.

In order to classify the CSG wells based on their production profile and thereby taking in to account flow characteristics, we considered the cumulative gas and water flow rates of the individual wells (Figure 1).

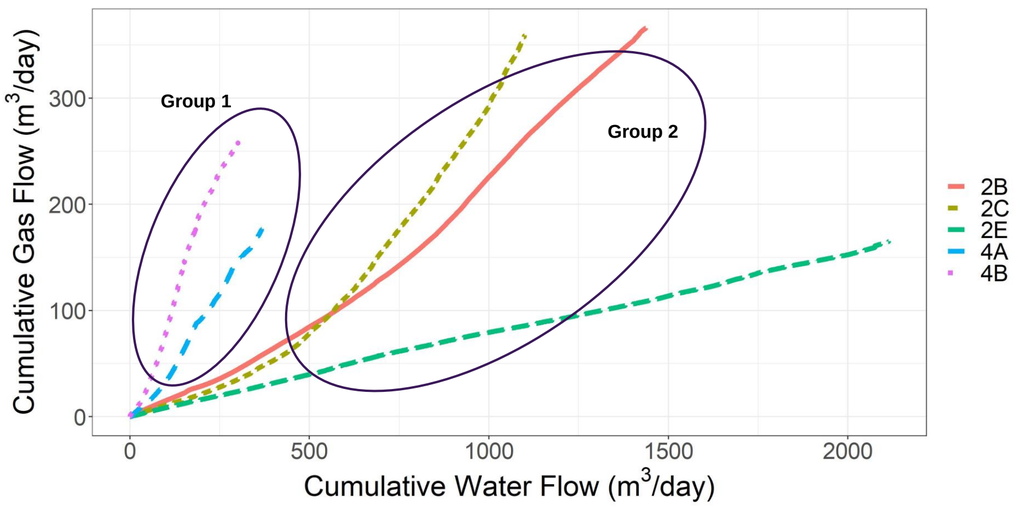

Figure 1: *Cumulative gas and water flow rates for the five wells.*

Model performance analysis

To assess the accuracy of the predictive models, a five-fold cross validation strategy was applied, where each fold contained data from a unique well (Table 1). During the i^{th}, i = (1, …, 5), iteration of the cross-validation, we used the i^{th} fold as the test set for a model fitted using the remaining folds. To estimate the hyper-parameters relating penalty terms during each iteration of the cross-validation, we performed internal cross-validation only using the data from the training folds (Figure 2). With this scheme, no data from the test well was used in fitting the model.

Well	OLS	OLS_C	OLS_I	LASSO	$LASSO_I$	Ridge	$Ridge_I$	Elastic Net	$Elastic\ Net_I$	NN
2B	5	4	9	5	9	5	8	5	9	**5**
2C	13	11	12	13	13	12	9	12	14	**8**
2E	**5**	6	13	5	13	6	16	5	14	15
4A	29	38	17	29	17	26	23	29	18	**14**
4B	35	34	45	35	45	40	36	36	30	**20**
ALL	12	11	*14*	*12*	*14*	*11*	*15*	*11*	*15*	**10**

Table 1: *Comparison of the median relative absolute error** in predicting the FBHP using different techniques. The overall estimate is obtained by collating the actual and the predicted FBHP during the cross-validation.*

$$** \text{ Absolute Relative Error} = \frac{(|\text{True value} - \text{Predicted value}|)}{\text{True value}}$$

Subscript C denotes that the categorical variable for location is used in the model fitting
Subscript I denotes that all pairwise between variables are included in the model.

Predictions of the models

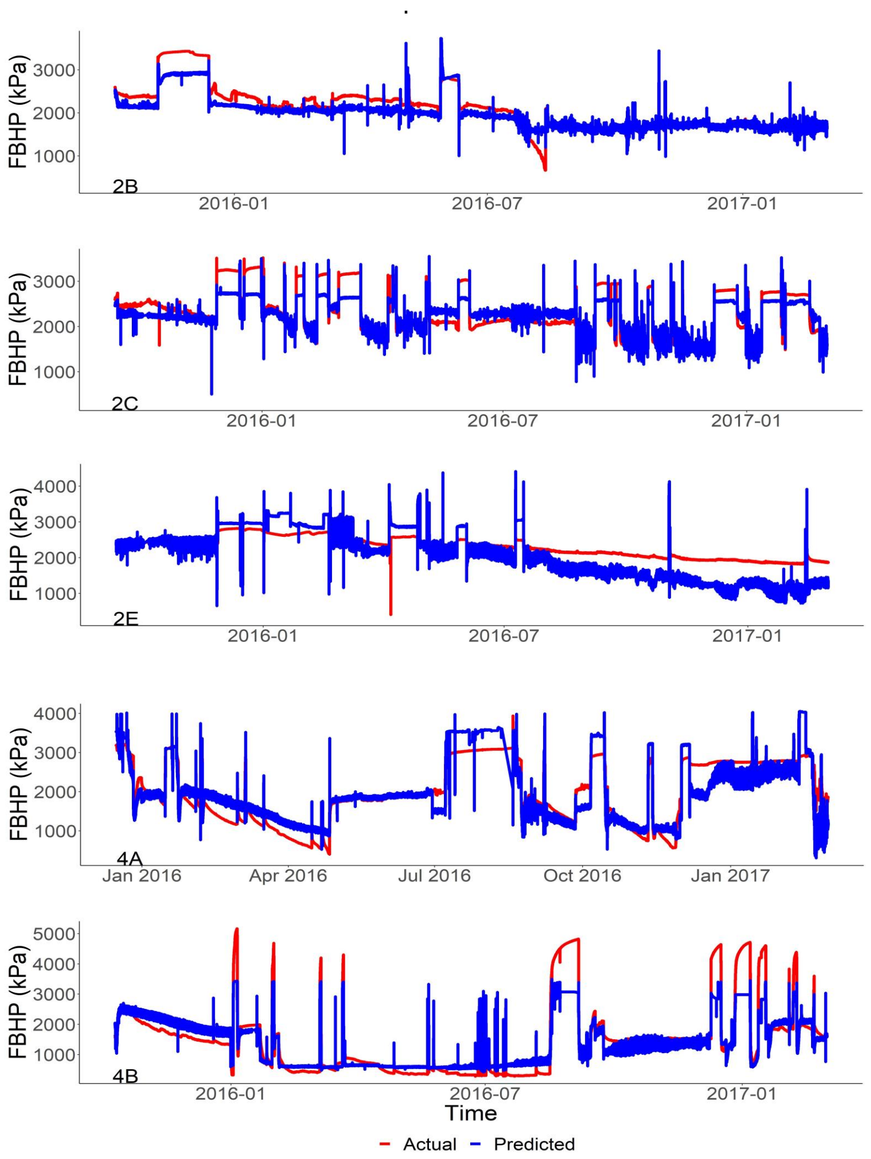

Figure 2: *Comparison of the predicted FBHP using the neural network approach with the actual (measured) FBHP. When predicting the FBHP for a particular well, the data for that well was not used in the model fitting.*

Summary

- ✓ The neural network approach outperformed the linear regression models with the lowest root mean square error (RMSE) and absolute relative errors in prediction.
- ✓ This study provides evidence that a small set of surface and sub-surface measurements obtained at coal seam gas wells can be used in the prediction of FBHP.

Research with real world impact

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