Genetic Programming for Reservoir Modeling and Characterization

Georesources

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Introduction

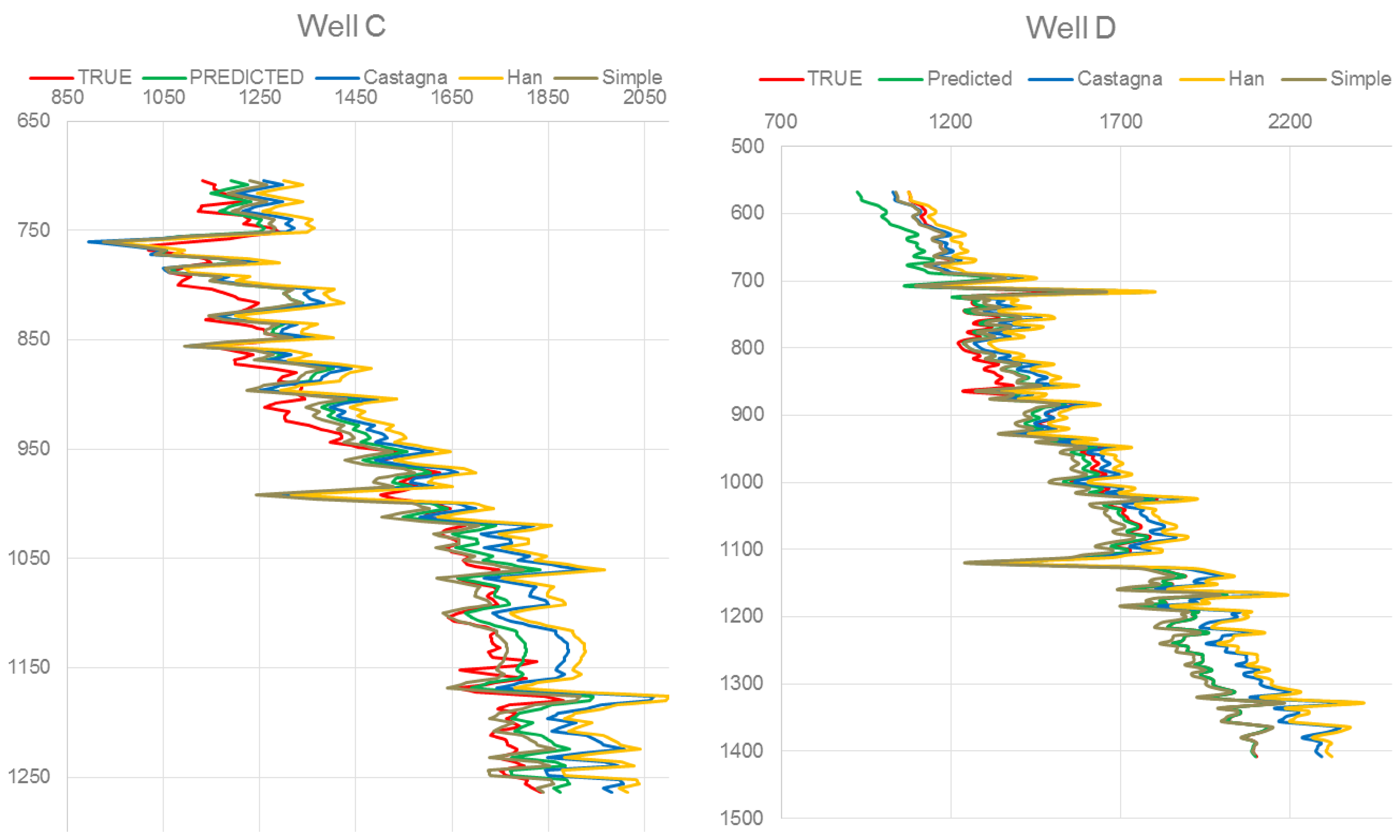
Recent developments in machine learning techniques, associated with increasing computational power and a marked increase in available data, generate great developments in data processing capabilities, and allow profound insights on natural and anthropogenic phenomena.

This work uses symbolic regression, a subset of genetic programming, in order to predict petrophysical properties values at well locations.

Frequently, many petrophysical properties at well locations are not measured, since their measurement can be costly. These properties are then derived from other (measured) properties using empirical correlations.

However, many of these correlations are valid only for particular geological settings, where they were derived. However, usage of those formulas in oil basins other than the ones intended is widespread.

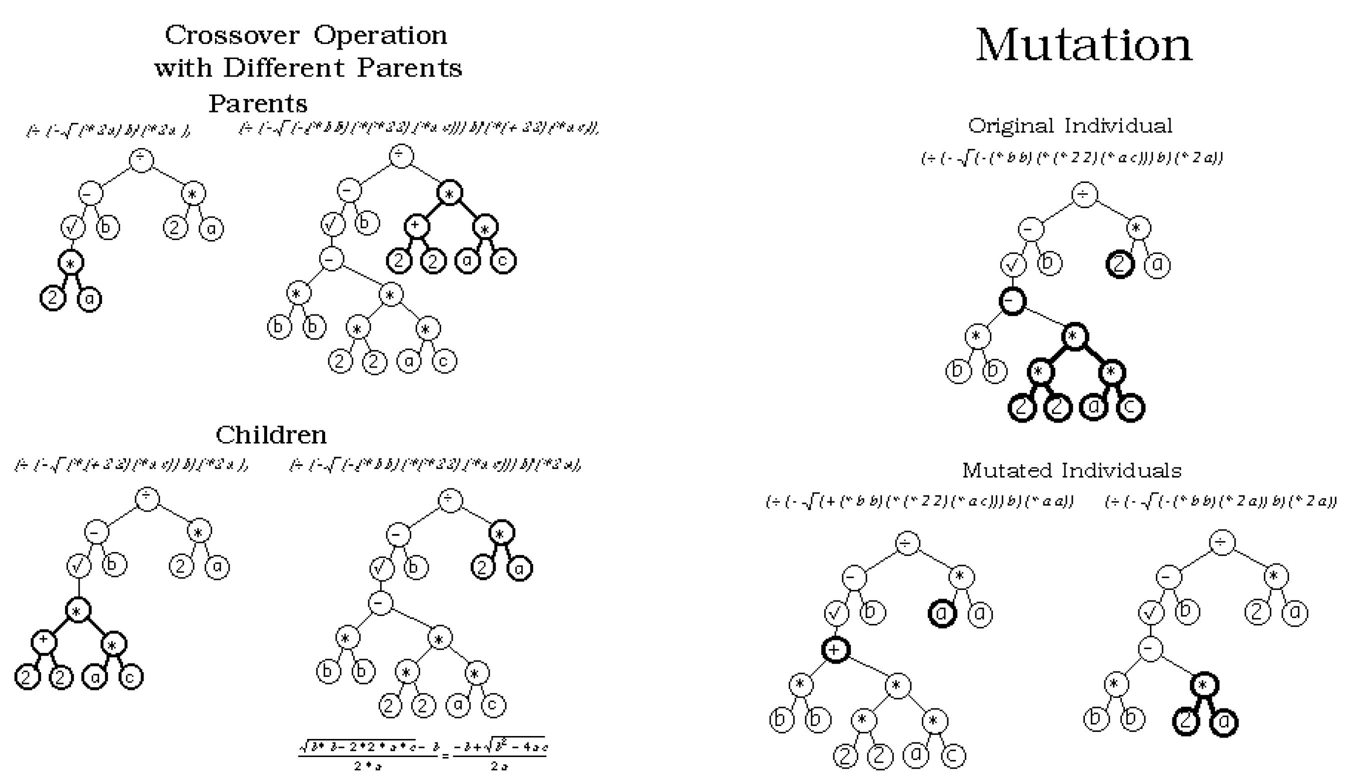
The aim of this work is to use symbolic regression as a method to generate equations that relate measured properties to unavailable ones.



Real and predicted Vs values at two wells - Green and brown show results of the presented method

Method

Symbolic regression is a method that searches a function space for a model that provides the best adjustment to some data, using a genetic algorithm as an optimization procedure. Random functions are generated and their adjustment to the data is measured. The best-fitting functions are then combined, using crossover and mutation, to generate new functions, which over several generations, allows a convergence to a optimal function.



Generating new functions from previous best fitting ones

Case study

The method was applied to a set with four oil wells, in order to predict S-wave velocity, using P-wave velocity and two-way travel time, a depth surrogate. Two wells were used as input for function discovery, and two other wells were used to validate the discovered relations. Two discovered functions, a simple and a more complexed one were compared with two widely used empirical functions (Castagna's and Han's), and with the measured S-wave velocity.

Well	Method	R^2	Average absolute error
Well C	Han	0.59	111.63
	Castagna	0.59	81.79
	Simple Aprox.	0.59	57.58
	Complex Aprox.	0.65	56.93
Well D	Han	0.99	110.97
	Castagna	0.99	78.50
	Simple Aprox.	0.98	47.34
	Complex Aprox.	0.98	19.23

Results and discussion

Results show an improvement over the traditionally used equations in both wells, especially for the more complex best-fitting solution. However, even the simpler solution, in the same form as Han and Castagna equations, has some improvement over those methods. The method shows good potential for substitution of general empirically derived equation with case dependent, data drives solutions for several petrophysical properties.

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