subtitles

Good morning, my name is Gaspar Salas Ruelas and I am going to tell you about my poster, which is entitled Fitting variogram models based on estimation errors and variances using genetic algorithms. This poster is about fitting variograms using genetic algorithms, which deals with to find the best adjustment model through ordinary kriging that generates the best spatial interpolation results for the characteristic being analyzed, which in this case is the hydraulic head which corresponds to "El Palmar" aquifer.

This work proposes a new multi-objective cost function where this nonlinear optimization problem contains three objectives. The first is to obtain the best fitting between the experimental and the theoretical variogram. Secondly, the aim is to minimize the difference between the measured values and the ordinary kriging estimates (by the root mean square error). And thirdly, the objective is minimized the variances of the error in the estimation by standard mean square error.

Different methods proposed for variogram adjustment can be found in the specialized literature. Li et al. (2018) proposed an interpolation-oriented fitting method based on genetic algorithms where they used a robust estimator for variogram estimation; Zhang et al. (2021) proposed a hybrid algorithm based on particle swarm and artificial fish swarm which has high optimization capacity and high precision. Jo & Pyrcz (2022) proposed the use of a convolutional neural network to fit the semivariogram; Li et al. (2022) used a new spatial interpolation method based on a deep neural network for variogram fitting and ordinary kriging estimates; Miranda & Souto de Miranda (2011) proposed a method that increases the overall efficiency of a robust variogram estimator, called the multiple variogram estimator.

This research work could be taken as a continuation of the work carried out in (Li et al., 2018) in which an objective function was used where for the adjustment of variograms the adjustment of the experimental variogram with the variogram is taken into account. theory and the goodness of fit between the values predicted by the model through kriging and the values that are used as a database, having as a novelty for this work the addition of the variance of the error in the estimation of the objective function as an adjustment parameter. This nonlinear optimization problem contains three secondary objectives. The first is to obtain the best fit between the experimental variogram and the function of the theoretical variogram. Secondly, the aim is to minimize the difference between the measured values and the ordinary kriging estimates (measured with the root mean square error) and thirdly, the objective is that the variances of the error in the estimation are well represented by the selected model (using the standard mean square error).

In section C we can observe the methodology where an optimal adjustment of the variogram is proposed that simultaneously considers the spatial structure, the precision in the interpolation and a good variance of the error in the estimation, it can be observed that corresponding to the adjustment of the variogram is denoted in Equation 1, where a sum of the squared errors between the values of the experimental variogram and the corresponding ones for the same distance for the theoretical variogram is used.

To calculate the error in the prediction of the hydraulic head, which is shown in equation 2, the root mean square error is used, where it is calculated with the root of the mean value of the differences between the hydraulic values. head measured in the field with the estimated hydraulic head data at each of these positions resulting from interpolation using ordinary kriging.

Which corresponds to the term associated with the variance of the error in the estimation, shown in equation 3, is evaluated with the standard mean square error, which reflects the relationship between the squared estimation errors and the variance of the estimation error in each point.

It is worth mentioning that within the objective function it was decided to introduce the term of the variance of the error in the estimation as the subtraction of one minus the value of the calculation of the error in the estimation, which would have to be the closest to zero. In this implementation, the sum of the weights in equation 4 must be 1. According to these restrictions and equations (1), (2) and (3), the final objective function is the one that It is shown in equation 4.

In section D we can observe the results of this investigation, in a first instance in section D.1 the results obtained by means of the optimization oriented to the adjustment of the theoretical variogram to the experimental variogram by means of genetic algorithms were analyzed, it is observed that the best model of The adjustment for this case is the Gaussian model, so for the experimentation the Gaussian model was used, it is also worth mentioning that the data was standardized to have the same error range for all the data that was introduced to the objective function, the results of this analysis are shown in table 1 where the adjustment parameters "nugget, sill and range" are seen, this variogram adjustment with the Gaussian model can be look at figure 1.

In section D.2 we can observe a comparison between the results that we have with the objective function without adding the variance of the error in the estimation that corresponds to table 2 and the results that we have by adding the variance of the error in the estimation as a parameter of optimization to the objective function which its summary is observed in Table 3, as can be observed in the summary of statistics of each table, for the results where the variance of the error in the estimation is not taken into account, we could have better values in what corresponds to the other two parameters 'variogram adjustment and interpolation adjustment', however, if we can observe the results that we obtain in the variance of the error in the estimation, they are somewhat incorrect, reaching values far removed from what we would expect as optimal, which for this parameter would be 1, therefore, as we can see in table 3 by adding the variance of the error in the estimation to the function The objective analysis generates very good values for this parameter, which are between 1.03 and 1.43.

Finally, in section D.3 the importance of adding the variance of the estimation error to the objective function is verified. For this, an experiment was compared where there was the same error in the estimation of the hydraulic head, but with a value very different from what corresponds to the variance of the error in the estimation, taking for the experiment 'observed in the figure 2' an error value in the estimation of the hydraulic head of 0.24m and a value of the variance of the error in the estimation of 1 (blue line) against a value of 20.81 (orange line). With this experiment we can see that the models where there is a variance value of the error in the estimate closer to the optimal value of 1, the values of the estimate (blue line of the experiment) disagree less with the measured data compared to the data with a greater variance of the error in the estimation (observed in the orange line).

Finally, in figure 3 we have a comparison of experiments where an experiment with an error in the prediction of the hydraulic head of 0.26 (blue and orange line) is compared against a model where there is an error in the hydraulic head prediction = 0.27 (gray line).

as conclusions which are found in section E of this poster, we have that, the cost function proposed in this paper optimizes the variance of the hydraulic head estimate. The variance of the estimation error associated with the precision of interpolation and fitting of the theoretical and experimental variogram, results in precise estimates with low dispersion. The experiments results show that the same root mean square error can be obtained with different variances. This result demonstrates the importance of the variance of the estimation error in the objective function. Although the variance of the estimation error is important, the term with the greatest weight is the error in the estimation of the hydraulic head.