Question

You are asked to estimate net to gross ratio (NTG) for the next vertical well given 3 previously drilled vertical wells. Spatial data and NTG for the previously drilled wells are given in the table below.

	X	Y	NTG
Well 1	600	800	0.25
Well 2	400	700	0.43
Well 3	800	100	0.56

The global stationary mean of net to gross ratio is 0.38. Its standard deviation is 0.05 and variance is equal to sill which is equal to 0.0025. Assume that the base variogram is isotropic, spherical with a range of 700 m (no nugget).

a) The first candidate well location is 500 m, 500 m. Assuming the base case isotropic spherical variogram work out the simple kriging weights, estimate, estimation variance and the local P10 and P90 values assuming the local uncertainty distribution is Gaussian. Comment on the weights.

b) The geologists and reservoir modelers have determined that the variogram model uncertainty in range is P10=300 m and P90 = 1100 (still anisotropic). How does this impact the estimate and uncertainty in the estimate? Report the range P10, base case and P90 kriging estimates and estimation variance in a table. Comment on the impact of variogram range on the weights and the estimate. Repeat with base case range and relative nugget effect (% of sill) 10%, 50% and 90%.

c) Move the new well location to (X=250 m, Y=650 m). Use base case variogram (isotropic range equal to 700 m, no nugget). Report the weights, estimate and P10 and P90 based on the estimation variance (assuming Gaussian distribution again). Comment on the weights.

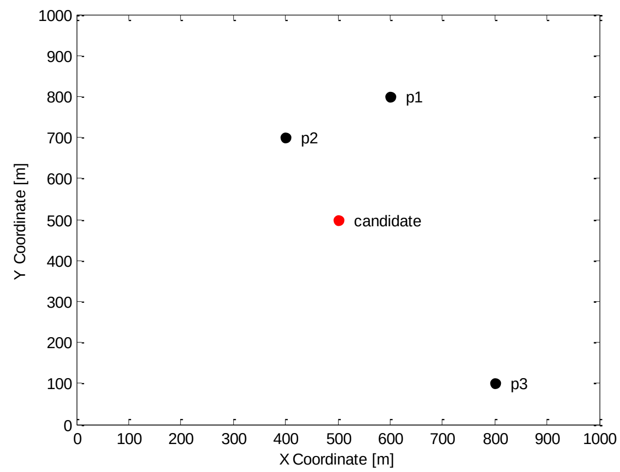
d) Consider location X=100 m, Y = 200 m, with the base case variogram range and no nugget. What are the weights, estimate and P10, P90 (assuming Gaussian distribution)? Explain the value of the weights.

Solution

Since the mean value is provided, we can go with simple kriging where the calculation procedure is shown below:

a) First, we need distance matrix:

$d_{1,i}$	$d_{2,i}$	$d_{3,i}$	$d_{0,i}$
0	224	728	316
224	0	721	224
728	721	0	500



Then, we need to calculate variogram matrix from the equation of spherical model, which is given in the previous lecture notes. Note that C_o is nugget effect, C is sill minus nugget effect, h is lag distance (from the distance matrix) and a is range. From the spherical model, the variogram matrix is calculated as follows:

$\gamma(d_{1,i})$	$\gamma(d_{2,i})$	$\gamma(d_{3,i})$	$\gamma(d_{0,i})$
0.000000	0.001157	0.002500	0.001579
0.001157	0.000000	0.002500	0.001157
0.002500	0.002500	0.000000	0.002223

Then we calculate covariance matrix from the equation given for stationary field:

$$C(h) = \sigma^2 - \gamma(h) \tag{1}$$

And covariance matrix becomes:

$C(d_{1,i})$	$C(d_{2,i})$	$C(d_{3,i})$	$C(d_{0,i})$
0.002500	0.001343	0.000000	0.000921
0.001343	0.002500	0.000000	0.001343
0.000000	0.000000	0.002500	0.000277

Then taking the inverse of three columns and multiplying with fourth column gives us lambda and other estimates as following:

w_1	w_2	w_3	estimate	variance	$P10$	$P90$
0.1124	0.4768	0.1108	0.4092	0.0017	0.3559	0.4624

As might expected the closes value p2 is getting more weight.

b) Changing variogram range:

Range = 300 Nugget Effect = 0%

w_1	w_2	w_3	estimate	variance	$P10$	$P90$
-0.0080	0.0897	0	0.3855	0.0025	0.3217	0.4493

Range = 700 Nugget Effect = 0%

w_1	w_2	w_3	estimate	variance	$P10$	$P90$
0.1124	0.4768	0.1108	0.4092	0.0017	0.3559	0.4624

Range = 1100 Nugget Effect = 0%

w_1	w_2	w_3	estimate	variance	$P10$	$P90$
0.1584	0.5484	0.2546	0.4327	0.0011	0.3906	0.4748

Changing nugget effect does not affect the estimate, it only affects the estimation error (variance).

Range = 700 **Nugget Effect = 0%**

w_1	w_2	w_3	estimate	variance	$P10$	$P90$
0.1124	0.4768	0.1108	0.4092	0.0017	0.3559	0.4624

Range = 700 **Nugget Effect = 10%**

w_1	w_2	w_3	estimate	variance	$P10$	$P90$
0.1278	0.4217	0.0997	0.4024	0.0019	0.3436	0.4613

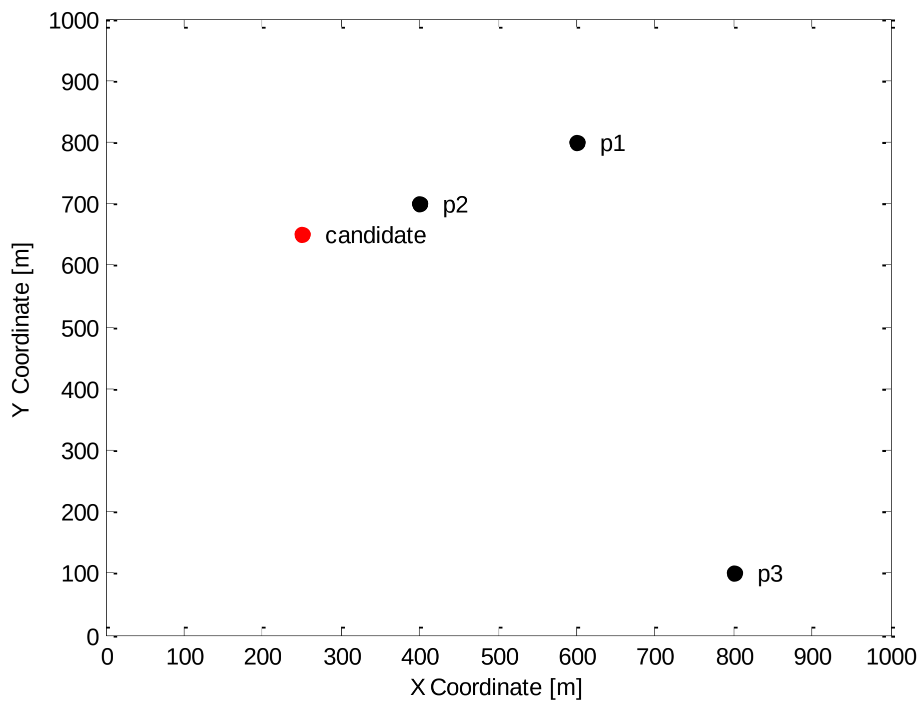
Range = 700 **Nugget Effect = 50%**

w_1	w_2	w_3	estimate	variance	$P10$	$P90$
0.1208	0.2361	0.0554	0.3861	0.0023	0.3099	0.4622

Range = 700 **Nugget Effect = 90%**

w_1	w_2	w_3	estimate	variance	$P10$	$P90$
0.0341	0.0519	0.0111	0.3802	0.0025	0.2919	0.4684

c)

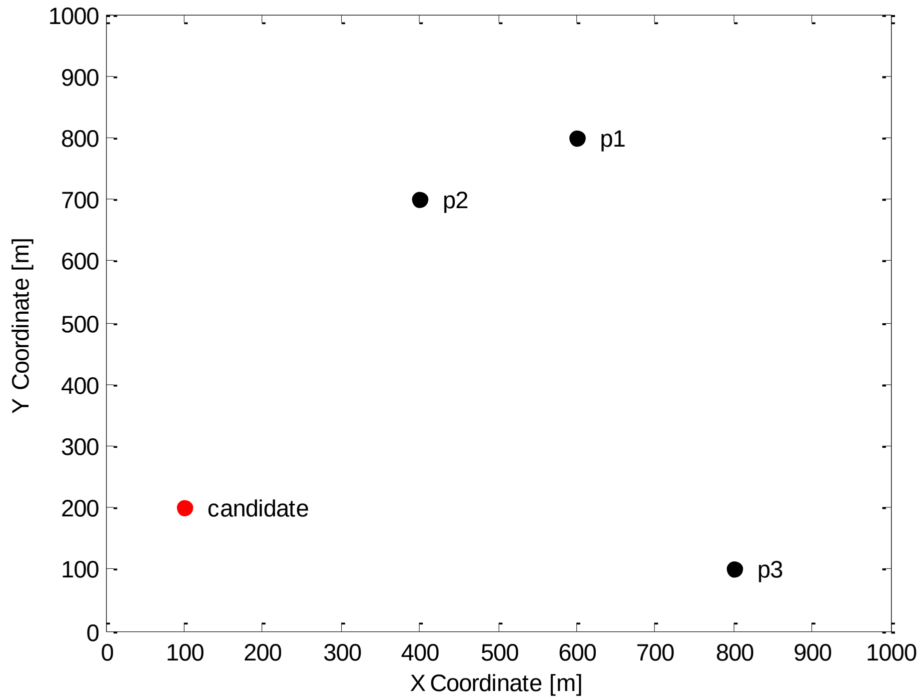


$d_{1,\text{can.}}$	$d_{2,\text{can.}}$	$d_{3,\text{can.}}$
381	158	778

Range = 700   Nugget Effect = 0%

w_1	w_2	w_3	estimate	variance	$P10$	$P90$
-0.1317	0.7377	0	0.4340	0.0014	0.3868	0.4812

d)



$d_{1,\text{can.}}$	$d_{2,\text{can.}}$	$d_{3,\text{can.}}$
781	583	707

Range = 700   Nugget Effect = 0%

w_1	w_2	w_3	estimate	variance	$P10$	$P90$
-0.0298	0.0555	0	0.3867	0.0025	0.3226	0.4507