FIG WORKING WEEK 2017

Helsinki Finland

29 May - 2 June 2017

Surveying the world of tomorrow -
From digitalisation to augmented reality

Organised by

Platinum Sponsors:

Centre of Space Techniques Division of Space Geodesy

Computation of Continuous Displacement Field from GPS Data -Comparative Study with Several Interpolation Methods

BELHADJ.ATTAOUIA, KAHLOUCHE.SALEM, GHEZALI.BOUALEM, and GOURINE.BACHIR.

Belhadj. Attaouia (Algeria)
battaouia@gmail.com

Problematic

In a geodesic network dedicated to monitoring of *Structures*

- Observations are discontinuous.
- The deformations studies belongs to the continuous domain

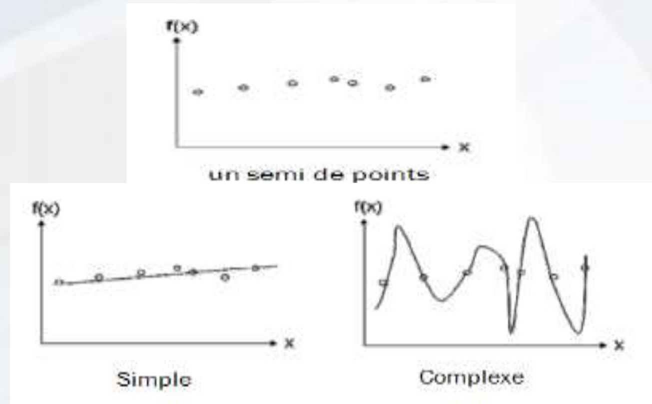
The solution uses ***Interpolation tools*** :

Estimating the **value** of a **quantity at a site** from samples of this magnitude collected at **other sites** [***Bosser, 2012***].

Study Objectives

- Densification of spatial estimation based on observations is important in meteorology and geology, etc. because It's impossible to collect observations at any point (cost, inaccessibility. Etc.)
- So the objectives of this study is using different models for choice the optimal method, build a tool to define to each sample the optimal one derived.

Design of an Interpolation Model



- Choice of the type of interpolation (***Simple*** or ***Complex***)
    - Estimation of its quality

$$\mathrm{ME} = \frac{1}{n}\sum_{i=1}^{n}(\tilde{z}(S_i) - z(S_i))$$

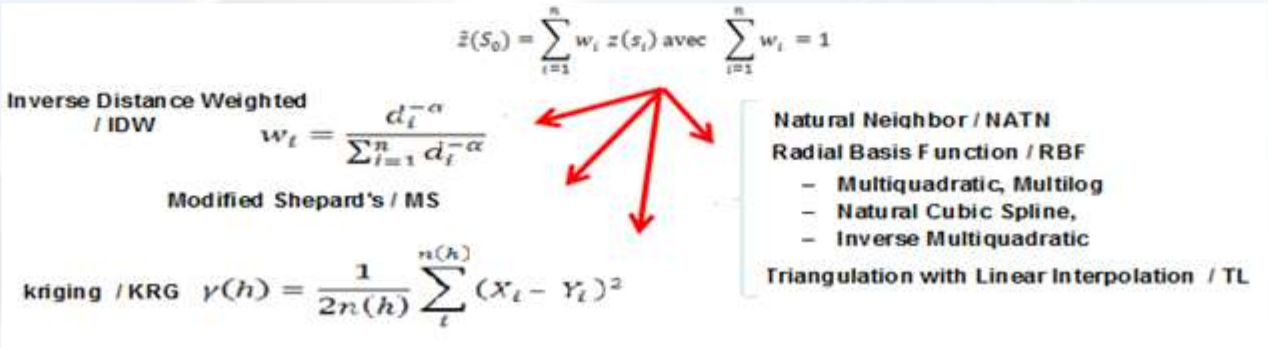
$$\sigma x = \sqrt{E[X^2] - E[X]^2}$$

Min	Max	Moyenne	Médiane	STD	MAE	RMSE
0	0.2220	0.1110	0.1110	0.1098	0.1087	0.1562
-0.0808	0.1734	0.0104	0	0.0344	0.0148	0.0359
-0.0830	0.2000	0.0103	0	0.0362	0.0157	0.0376
-0.0799	0.2047	0.0110	0	0.0367	0.0149	0.0383
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

$$\mathrm{RMSE} = \left(\frac{1}{n}\sum_{i=1}^{n}(\tilde{z}(S_i) - z(S_i))^2\right)^{0.5}$$

Methodology

- Different formulation of Interpolation methods
- Exact methods to preserve the observed values
- Program with " ***Scripter Tool of Surfer software*** "



Flowchart of Methodology

Test data
- Data sets of tests (Xi, Yi, Zi)

Treatment Program
- Application of several interpolation **algorithms**
- Interpolation **Grids**
- Grids **Differences** (**Explicit** grid and **Interpolation** grid)

Comparison of results
- **Grid Difference Residues**
- Cross validation **HOV:** hold out validation
- Cross validation **LOOV**: Leave one out validation

Preliminary study

$Z_i = Fn(X_i, Y_i)$, four fonction tests

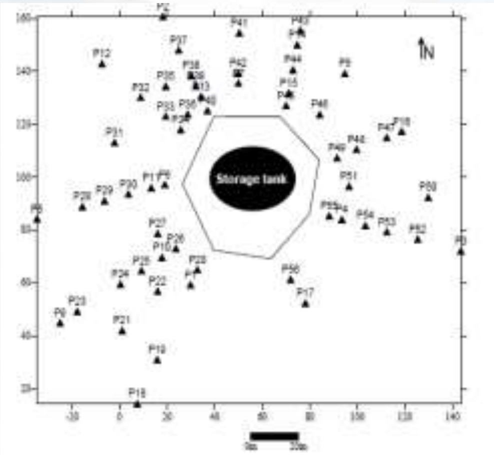
- ✓ $F_1(x, y) = (\tanh(9y-9x)+1)/9$
- ✓ $F_2(x, y) = (1.25+\cos(5.4y))/6(1+(3x-1)2)$
- ✓ $F_3(x, y) = e(-81/16)((x-0.5)2+(y-0.5)2)/$
- ✓ $F_4(x, y) = e(-81/4)((x-0.5)2+(y-0.5)2)/3$

[C. CARUSO,& AL, 1998]

Type of comparison	Regular sample	Random sample	Digital sample
Grids of Difference	NEAN	NEAN	NEAN, RBF-S
	TL	KRG, MS	TL
	IDW, MS, RBF- Mlog	TL , **RBF-M**	MS, RBF-M
LOOV	RBF-S , MS	MS	MS
	RBF-M, TL	TL, NEAN	TL
	KRG, NEAN, RBF- Mlog	KRG, RBF- Mlog, RBF-S	NEAN
HOV	MS	MS	MS
	TL	TL, NEAN	TL, NEAN
	NEAN	KRG	KRG

Application on real Area

- Site surrounding the Industrial reservoir at ***Arzew, Algeria***
- Set of ***56 GPS*** observations between two campaigns (2000-2006).



Results

LOOCV STATISTICS ERRORS OF DN

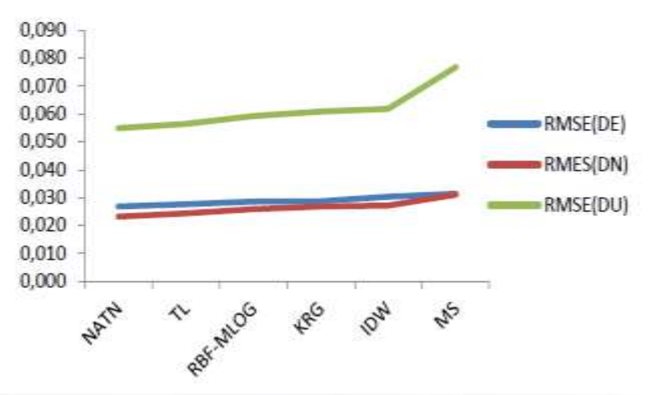
	MEAN(m)	PEARSON	RMSE(m)
Natural Neighbor	0,004	**0,295**	**0,023**
Triangulation Linear	0,003	0,238	0,024
Kriging	-0,002	0,242	0,026
Radial Basis Function	-0,001	**0,101**	**0,027**
Modified Shepard's	-0,005	0,110	0,027
Inverse Distance	-0,003	0,240	0,031

LOOCV STATISTICS ERRORS OF DU

	MEAN(m)	PEARSON	RMSE(m)
Natural Neighbor	-0,009	**0,166**	**0,055**
Triangulation Linear	-0,010	0,139	0,056
Inverse Distance	-0,001	0,164	0,059
Kriging	0,003	0,051	0,061
Radial Basis Function	0,002	**0,050**	**0,062**
Modified Shepard's	0,011	0,108	0,077

LOOCV STATISTICS ERRORS OF DE

	MEAN(m)	PEARSON	RMSE(m)
Natural Neighbor	0,002	**0,250**	**0,027**
Triangulation Linear	0,004	0,065	0,028
Radial Basis Function	0,000	**0,015**	**0,029**
Kriging	0,000	0,027	0,029
Inverse Distance	0,000	0,029	0,030
Modified Shepard's	0,001	0,085	0,031



Conclusion

- ✓ This study compares the results of interpolated unknown displacement field with different exact methods *(all reliable),*
- ✓ ***Natural Neighbor*** as the best interpolator *(minimal RMSE);*
- ✓ ***Radial basis function-Multilog*** or ***kriging*** give a bests representation of a continues displacement field ***(without any restriction geometric)***,

Thank You