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Optimization of Segment Point Distribution of Baselines

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- Methodology
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Introduction

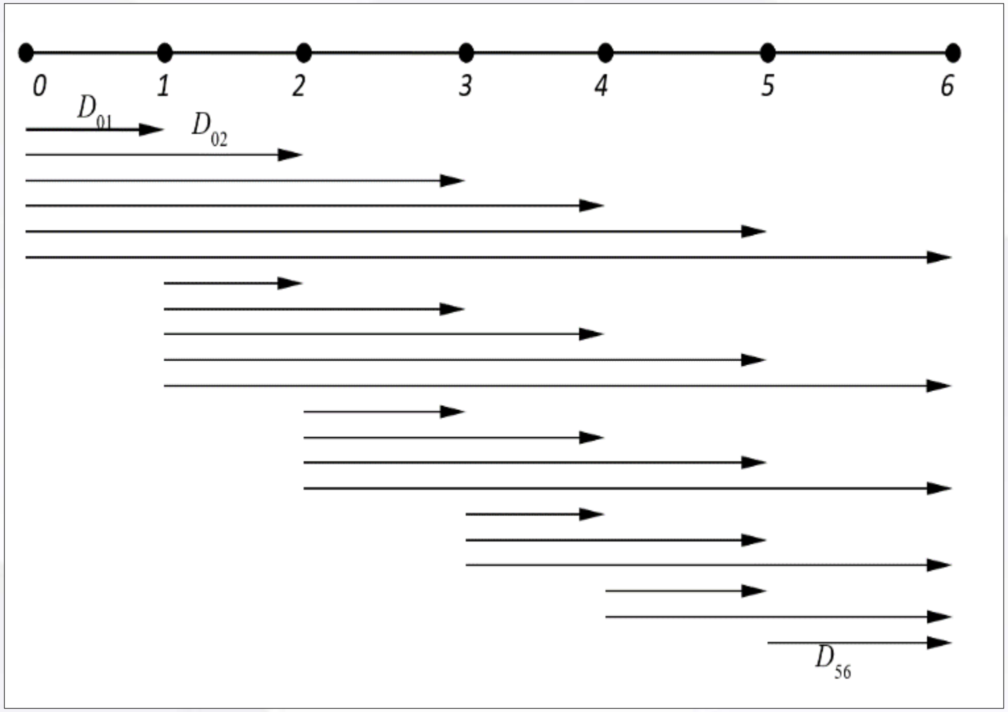
Introduction

Two important systematic errors of Total Station when measuring the distances.

- Additive constant(K)
- Scale correction(R)

Methodology

Baseline stations



The six-segment field baselines

The calibration is done by the distance comparison method on an outdoor station-to-station baseline which has been precisely measured in advance.

Methodology

$$V = AX - L$$

$$V_{21\times1} = (v_{01} \quad v_{02} \quad \cdots \quad v_{56})^T$$

$$A_{21\times1} = \begin{pmatrix} 1 & 1 & 1 & 1 \\ D_{01} & D_{02} & \cdots & D_{56} \end{pmatrix}^T$$

$$X_{21\times1} = (K \quad R)^T$$

$$L_{21\times1} = (l_{01} \quad l_{02} \quad \cdots \quad l_{56})^T$$

$V_{21\times1}$ is the vector of residuals,
$A_{21\times1}$ is the coefficient matrix,
$X_{21\times1}$ is the vector of parameters,
$L_{21\times1}$ is the vector of numeric term.

01

02

03

$$v_{ij} = K + R \times D_{ij} - l_{ij}$$

（i=0,1, …5； j=1， 2,…， 6， $i \neq j$）

$$l_{ij} = D_{ij}^t - D_{ij}$$

D_{ij}^t is the given or “true” distance ,
v_{ij} is the residual.

$$X = (A^T PA)^{-1} A^T PL$$

$$X = \begin{pmatrix} K \\ R \end{pmatrix} = \frac{1}{\left(\sum\sum D_{ij}\right)^2 - n \cdot \sum\sum D_{ij}^2} \times \begin{pmatrix} \sum\sum D_{ij} \cdot \sum\sum D_{ij} l_{ij} - \sum\sum D_{ij}^2 \cdot \sum\sum l_{ij} \\ \sum\sum D_{ij} \cdot \sum\sum l_{ij} - n \cdot \sum\sum D_{ij} l_{ij} \end{pmatrix}$$

based on the least-squares principle

Methodology

The covariance matrix of parameters $Q=\left(A^T PA\right)^{-1}$ is

$$Q=\begin{pmatrix} Q_{KK} & Q_{KR} \\ Q_{RK} & Q_{RR} \end{pmatrix}=\frac{1}{n\cdot\sum\sum D_{ij}^2-\left(\sum\sum D_{ij}\right)^2}\begin{pmatrix} \sum\sum D_{ij}^2 & -\sum\sum D_{ij} \\ -\sum\sum D_{ij} & n \end{pmatrix}$$

$$m_0=\sqrt{\frac{V^T V}{n-2}}$$

$$m_K=m_0\sqrt{Q_{KK}}$$

$$m_R=m_0\sqrt{Q_{RR}}$$

m_0 , m_K and m_R are the standard deviations of a measured distance, additive constant, and scale correction, respectively.

Results

Scheme	Baseline length (km)	Segment baseline length(m)						Q_{KK}	Q_{RR}
		d_{01}	d_{12}	d_{23}	d_{34}	d_{45}	d_{56}		
1	0.768	24	96	216	264	120	48	0.174	0.796
2	**0.768**	**24**	**48**	**120**	**264**	**216**	**96**	**0.163**	**0.800**
3	0.768	24	120	264	216	96	48	0.174	0.800
4	0.768	24	96	264	216	120	48	0.174	0.800
5	0.768	24	120	216	264	96	48	0.174	0.801
6	**0.768**	**24**	**48**	**120**	**216**	**264**	**96**	**0.161**	**0.806**
7	0.768	24	48	96	264	216	120	0.160	0.809
8	0.768	24	48	96	216	264	120	0.157	0.810
…	…	…	…	…	…	…	…	…	…
109	**0.768**	**24**	**48**	**120**	**216**	**96**	**264**	**0.162**	**0.972**

Segment points are dense on both ends and sparse in the middle of the baseline.

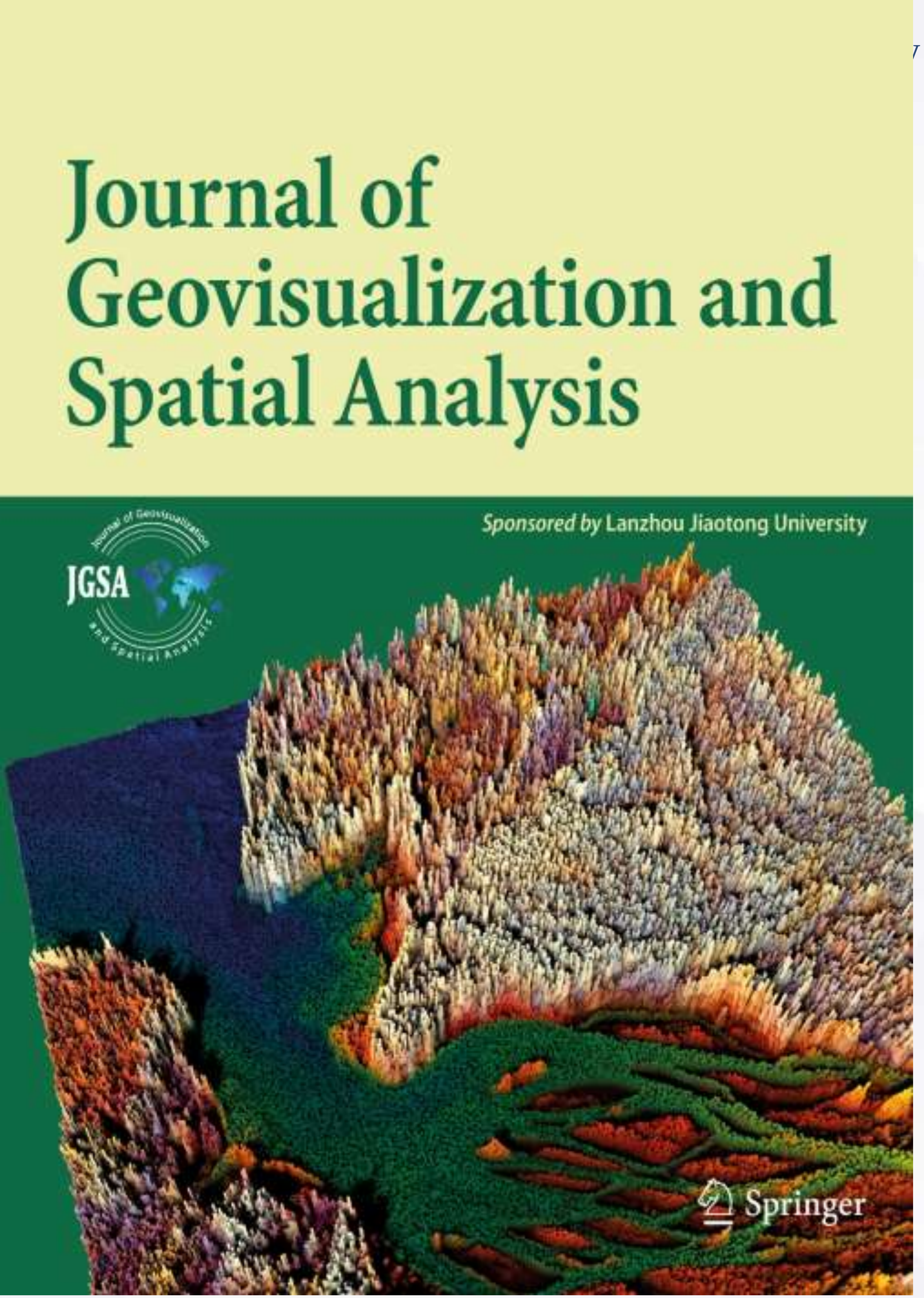
Results

Scheme	Baseline length (km)	Segment baseline length(m)							
		d_{01}	d_{12}	d_{23}	d_{34}	d_{45}	d_{56}	Q_{KK}	Q_{RR}
109	**0.768**	**24**	**48**	**120**	**216**	**96**	**264**	**0.162**	**0.972**
…	…	…	…	…	…	…	…	…	…
319	0.768	216	120	48	96	24	264	0.166	1.425
320	0.768	216	96	24	120	48	264	0.166	1.428
321	0.768	216	48	96	120	24	264	0.172	1.434
322	0.768	216	96	48	120	24	264	0.169	1.437

Segment points are sparse on both ends and dense in the middle of the baseline.

Conclusions

- The distribution of segment points of the baseline has influence on the additive constant and scale correction;
- The change of Q_{KK} are generally little, while the Q_{RR} varies greatly;
- The Q_{RR} are relatively greater when the distribution of the distances is arranged as long-short-long-long-short-long;
- For a certain length of the baseline, the scheme whose segment points distributed dense on both ends and sparse in the middle on the baseline is the best one.



THANK YOU!

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