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Application of linear transformation in numerical calculation

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ABSTRACT

The linear transformation is the most simple and the most basic transformation. Such as, the linear function is the most simple and the most basic function. The linear transformation is a main research object of linear algebra. This text uses a series of related knowledge of linear transformation thought in linear algebra, makes study and analysis finely to the position and application of the linear transformation thought in mathematics, and sieves several typical example.

Keywords: Linear transformation, Matrix, Numerical Calculation, The application

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INTRODUCTION

Linear transformation is one of the core content of linear algebra. It plays an important role in between the whole structure and linear vector space memory link. Concept of linear transformation is the transformation of coordinates in analytic geometry, some transformation in mathematical analysis to replace the generalization and abstraction. Its theory and methods in analytic geometry, differential equations and many other fields, and it has widespread application.

LINEAR TRANSFORMATION

Linear mapping

Definition 1 Suppose σ be a mapping from V to W. If you meet the following conditions, called σ is a mapping from V to W .

(1)For arbitrary $\xi,\eta\in V,\sigma(\xi+\eta)=\sigma(\xi)+\sigma(\eta)$

(2)For arbitrary $a\in F,\xi\in V,\sigma(a\xi)=a\sigma(\xi)$

Some basic properties of linear mapping:
Condition (1) and condition (2), in the definition 1, is the condition (3) equivalent conditions.
(3)For arbitrary $a,b\in F$ and $\xi,\eta\in V$

$$\sigma(a\xi+b\eta)=a\sigma(\xi)+b\sigma(\eta)$$

In fact, if the mapping $\sigma:V\to W$ satisfies the condition (1) and (2), for any $a,b\in F$ and $\xi,\eta\in V$,

$$\sigma(a\xi+b\eta)=\sigma(a\xi)+\sigma(b\eta)=a\sigma(\xi)+b\sigma(\eta)$$

Conversely, suppose (3) was established, made $a=b=1$, get condition (1); and $b=0$, get the condition (2). In the condition (2), $a=0$ get

$$\sigma(0)=0$$

In other words, the linear mapping will be zero vectors onto the zero vectors.
By (3), as the mathematical induction on n , easy to launch:

$$\sigma\left(a_1\xi_1+\cdots a_n\xi_n\right)=a_1\sigma\left(\xi_1\right)+\cdots a_n\sigma\left(\xi_n\right)$$

For arbitrary $a_1,\cdots a_n\in F$ and $\xi_1,\cdots\xi_n\in V$ are established.

Linear transformation
Let V be a vector space of a number field P .

Some basic properties of linear transformation,
1. Suppose A be a linear transformation of V , $A(0)=0$ and $A(-\alpha)=-A(\alpha)$.
2. Linear transformation keeps linear combination and linear equation invariant. If β is a linear combination of $\alpha_1,\alpha_2,\mathrm{L},\alpha_r$,

$$\beta=k_1\alpha_1+k_2\alpha_2+\cdots+k_r\alpha_r$$

Then after the linear transformation A , $A(\beta)$ is a linear combination of $A(\alpha_1),A(\alpha_2),\cdots,A(\alpha_r)$:

$$A(\beta)=k_1A(\alpha_1)+k_2A(\alpha_2)+\cdots+k_rA(\alpha_r)$$

If there is a linear relationship between $\alpha_1,\alpha_2,\cdots,\alpha_r$

$$k_1\alpha_1+k_2\alpha_2+\cdots+k_r\alpha_r=0$$

So

$$k_1A(\alpha_1)+k_2A(\alpha_2)+\cdots+k_rA(\alpha_r)=0$$

3. Linear transformation can change linear correlation vectors into linear dependent set of vectors.

Example [1]
Case 1 Suppose α be a nonzero vector in geometry space, each vector ξ to it in the α on the injection of transformation is a linear transformation, with Π_α expressed, formula is

$$\Pi_\alpha(\xi)=\frac{(\alpha,\xi)}{(\alpha,\alpha)}\alpha$$

Here $(\alpha,\xi),(\alpha,\alpha)$ denotes the inner product.

Case 2 In the linear space $P[x]$ or $P[x]_n$, differential quotient is a linear transformation. This transformation usually use $\mathcal{D}$ representative,

$$\mathcal{D}\left(f(x)\right)=f'(x)$$

MATRIX OF A LINEAR TRANSFORMATION
The definition of linear transformation matrix [2]

Definition 2 Suppose $\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n$ is a set of basis in n -dimensional linear space V which Belongs to the number field P . And $\mathcal{A}$ is a linear transformation of V . So the basis vectors can be linearly expressed as

$$\begin{cases}A\varepsilon_1=a_{11}\varepsilon_1+a_{21}\varepsilon_2+\cdots+a_{n1}\varepsilon_n\\ A\varepsilon_2=a_{12}\varepsilon_1+a_{22}\varepsilon_2+\cdots+a_{n2}\varepsilon_n\\ \qquad\cdots\quad\cdots\quad\cdots\\ A\varepsilon_n=a_{1n}\varepsilon_1+a_{2n}\varepsilon_2+\cdots+a_{nn}\varepsilon_n\end{cases}$$

With the matrix representation is

$$A(\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n)=\left(A(\varepsilon_1),A(\varepsilon_2),\cdots,A(\varepsilon_n)\right)=(\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n)A \tag{1}$$

Among them

$$A=\begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ & \cdots & \cdots & \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix}$$

Matrix A is called the matrix of linear transformation $\mathscr{A}$ on the base of $\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n$.

The related theorem [3]

Theorem 1 Suppose $\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n$ is a set of basis in linear space V, $\alpha_1,\alpha_2,\cdots,\alpha_n$ is n vector arbitrary in V. There is a linear transformation of $\mathscr{A}$

$\mathscr{A}\varepsilon_i=\alpha_i$, $i=1,2,\cdots,n$

Theorem 2 Suppose $\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n$ is a set of cardinality in n-dimensional linear space V which Belongs to the number field P. In this base, every linear transformation according to the formula (1) corresponding to a $n\times n$ matrix. This corresponds with the following properties.

(1) Linear transformation sum corresponding to the matrix sum.
(2) The product of linear transformation corresponding to the matrix product.
(3) The number product of linear transformation corresponding to the matrix number product.
(4) Invertible Linear Transformation corresponding to invertible matrix.

Theorem 3 Suppose matrix A is the matrix of linear transformation $\mathscr{A}$ on the base of $\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n$. On the base of $\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n$, vector ξ coordinate is $(x_1,x_2,\cdots,x_n)$ .So the $\mathscr{A}\xi$ coordinate, on the base of $\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n$, is $(y_1,y_2,\cdots,y_n)$ .And

$$\begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix}=A\begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{pmatrix}$$

Theorem 4 Suppose matrix of linear transformation of $\mathscr{A}$, which in linear space V, under the two bases of (2) and (3) are respectively A and B .From the base (2) to (3) the transition matrix is X ,and $B=X^{-1}AX$.

$$\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n \tag{2}$$

$$\eta_1,\eta_2,\cdots,\eta_n \tag{3}$$

Example [3]

Case 1 Suppose $\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_m$ is a set of basis in subspace W which belongs to n-dimensional linear space V $(n>m)$. It expanded a set of basis in V as $\varepsilon_1,\varepsilon_2,\cdots,\varepsilon_n$. Specifies a linear transform $\mathscr{A}$ meet

$$\begin{cases} A\varepsilon_i=\varepsilon_i, i=1,2,\cdots,m \\ A\varepsilon_i=0, i=m+1,\cdots,n \end{cases}$$

So the linear transformation $\mathscr{A}$ called a projection in subspace W. It is easy to find that

$\mathcal{A}^2 = \mathcal{A}$

Matrix of projection $\mathcal{A}$ under the base of $\varepsilon_1, \varepsilon_2, \cdots, \varepsilon_n$ is

$$\begin{pmatrix} 1 & & & & & & \\ & 1 & & & & & \\ & & \ddots & & & & \\ & & & 1 & & & \\ & & & & 0 & & \\ & & & & & \ddots & \\ & & & & & & 0 \end{pmatrix}$$

By determining a set of basis, established a mapping from linear transformation in n -dimensional linear space V which Belongs to the number field P to the $n \times n$ matrix.

Case 2 Suppose the matrix of linear transformation $\mathcal{A}$, which in three dimensional linear spaces V , under the base of $\varepsilon_1, \varepsilon_2, \varepsilon_3$ is

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

(1) Seeking the matrix of $\mathcal{A}$ under the base of $\varepsilon_3, \varepsilon_2, \varepsilon_1$.

(2) Seeking the matrix of $\mathcal{A}$ under the base of $\varepsilon_1, \kappa\varepsilon_2, \varepsilon_3$, among them $\kappa \in P$ and $\kappa \neq 0$.

Solving:

$$\mathcal{A}\varepsilon_1 = a_{11}\varepsilon_1 + a_{21}\varepsilon_2 + a_{31}\varepsilon_3$$
$$\mathcal{A}\varepsilon_2 = a_{12}\varepsilon_1 + a_{22}\varepsilon_2 + a_{32}\varepsilon_3$$
$$\mathcal{A}\varepsilon_3 = a_{13}\varepsilon_1 + a_{23}\varepsilon_2 + a_{33}\varepsilon_3$$

So

$$\mathcal{A}\varepsilon_3 = a_{33}\varepsilon_3 + a_{23}\varepsilon_2 + a_{13}\varepsilon_3$$
$$\mathcal{A}\varepsilon_2 = a_{32}\varepsilon_3 + a_{22}\varepsilon_2 + a_{12}\varepsilon_1$$
$$\mathcal{A}\varepsilon_1 = a_{31}\varepsilon_3 + a_{21}\varepsilon_2 + a_{11}\varepsilon_1$$

The matrix of $\mathcal{A}$ under the base of $\left(\varepsilon_3, \varepsilon_2, \varepsilon_1\right)$ is

$$\begin{bmatrix} a_{33} & a_{32} & a_{31} \\ a_{23} & a_{22} & a_{21} \\ a_{13} & a_{12} & a_{11} \end{bmatrix}$$

In the same way,

$$\mathcal{A}\varepsilon_1 = a_{11}\varepsilon_1 + (\frac{\alpha_{21}}{\kappa})\kappa\varepsilon_2 + a_{31}\varepsilon_3$$
$$\mathcal{A}\kappa\varepsilon_2 = \kappa a_{12}\varepsilon_1 + a_{22}\kappa\varepsilon_2 + \kappa a_{32}\varepsilon_3$$
$$\mathcal{A}\varepsilon_3 = a_{13}\varepsilon_1 + (\frac{\alpha_{23}}{\kappa})\kappa\varepsilon_2 + a_{33}\varepsilon_3$$

The matrix of $\mathcal{A}$ under the base of $\varepsilon_1, \kappa\varepsilon_2, \varepsilon_3$ is

$$\begin{bmatrix} a_{11} & \kappa a_{12} & a_{13} \\ \frac{\alpha_{21}}{\kappa} & a_{22} & \frac{\alpha_{23}}{\kappa} \\ a_{31} & \kappa a_{32} & a_{33} \end{bmatrix}$$

Case 3 Suppose V is a Two-dimensional linear space in the number field P, and $\varepsilon_1, \varepsilon_2$ is a set of basis. The matrix of linear transformation $\mathcal{A}$ under the base of $\varepsilon_1, \varepsilon_2$ is

$$\begin{bmatrix} 2 & 1 \\ -1 & 0 \end{bmatrix}$$

Calculating the matrix of $\mathcal{A}$ under another base of η_1, η_2 ,among them

$$(\eta_1, \eta_2) = (\varepsilon_1, \varepsilon_2)\begin{bmatrix} 1 & -1 \\ -1 & 2 \end{bmatrix}$$

So, the matrix of $\mathcal{A}$ under the base of η_1, η_2 is that

$$\begin{bmatrix} 1 & -1 \\ -1 & 2 \end{bmatrix}^{-1}\begin{bmatrix} 2 & 1 \\ -1 & 0 \end{bmatrix}\begin{bmatrix} 1 & -1 \\ -1 & 2 \end{bmatrix} = \begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} 2 & 1 \\ -1 & 0 \end{bmatrix}\begin{bmatrix} 1 & -1 \\ -1 & 2 \end{bmatrix} = \begin{bmatrix} 3 & 2 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} 1 & -1 \\ -1 & 2 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

Case 4 Suppose $\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4$ is a set of basis in four dimensional linear spaces V, known the matrix of $\mathcal{A}$ under the base of $\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4$ is

$$\begin{bmatrix} 1 & 0 & 2 & 1 \\ -1 & 2 & 1 & 3 \\ 1 & 2 & 5 & 5 \\ 2 & -2 & 1 & -2 \end{bmatrix}$$

Seeking the matrix of $\mathcal{A}$ under the base of $\eta_1 = \varepsilon_1 - 2\varepsilon_2 + \varepsilon_4$, $\eta_2 = 3\varepsilon_2 - \varepsilon_3 - \varepsilon_4$, $\eta_3 = \varepsilon_3 + \varepsilon_4$, $\eta_4 = 2\varepsilon_4$.
Solving:

$$(\eta_1, \eta_2, \eta_3, \eta_4) = (\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4)\begin{bmatrix} 1 & 0 & 0 & 0 \\ -2 & 3 & 0 & 0 \\ 0 & -1 & 1 & 0 \\ 1 & -1 & 1 & 2 \end{bmatrix}$$

So

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ -2 & 3 & 0 & 0 \\ 0 & -1 & 1 & 0 \\ 1 & -1 & 1 & 2 \end{bmatrix}^{-1}\begin{bmatrix} 1 & 0 & 2 & 1 \\ -1 & 2 & 1 & 3 \\ 1 & 2 & 5 & 5 \\ 2 & -2 & 1 & -2 \end{bmatrix}\begin{bmatrix} 1 & 0 & 0 & 0 \\ -2 & 3 & 0 & 0 \\ 0 & -1 & 1 & 0 \\ 1 & -1 & 1 & 2 \end{bmatrix}$$

$$=\begin{bmatrix} 2 & -3 & 3 & 2 \\ \frac{2}{3} & -\frac{4}{3} & \frac{10}{3} & \frac{10}{3} \\ \frac{8}{3} & -\frac{16}{3} & \frac{40}{3} & \frac{40}{3} \\ 0 & 1 & -7 & -8 \end{bmatrix}$$

Case 5 Two bases of P^3 of given [4]

$\varepsilon_1 = (1,0,1)$，$\eta_1 = (1,2,-1)$，

$\varepsilon_2 = (2,1,0)$，$\eta_2 = (2,2,-1)$，

$\varepsilon_3 = (1,1,1)$，$\eta_3 = (2,-1,-1)$。

The definition of linear transformation $\mathcal{A}$:

$\mathcal{A}\varepsilon_i = \eta_i$，$i = 1,2,3$。

(1) Write out the transition matrix from $\varepsilon_1, \varepsilon_2, \varepsilon_3$ to η_1, η_2, η_3.

(2) Write out the matrix of A under the base of $\varepsilon_1, \varepsilon_2, \varepsilon_3$.

(3) Write out the matrix of A under the base of η_1, η_2, η_3.

Solving:

$$\begin{bmatrix} 1 & 2 & 2 \\ 2 & 2 & -1 \\ -1 & -1 & -1 \end{bmatrix} = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix} X$$

$$X = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 & 2 & 2 \\ 2 & 2 & -1 \\ -1 & -1 & -1 \end{bmatrix} = \begin{bmatrix} -2 & -\frac{3}{2} & \frac{3}{2} \\ 1 & \frac{3}{2} & \frac{3}{2} \\ 1 & \frac{1}{2} & -\frac{5}{2} \end{bmatrix}$$

Because of

$$\mathcal{A}\varepsilon_i = \eta_i = \varepsilon_i A$$

So

$$(\eta_1, \eta_2, \eta_3) = (\varepsilon_1, \varepsilon_2, \varepsilon_3) A$$

$$A = X = \begin{bmatrix} -2 & -\frac{3}{2} & \frac{3}{2} \\ 1 & \frac{3}{2} & \frac{3}{2} \\ 1 & \frac{1}{2} & -\frac{5}{2} \end{bmatrix}$$

And

$$\begin{bmatrix} -2 & -\frac{3}{2} & \frac{3}{2} \\ 1 & \frac{3}{2} & \frac{3}{2} \\ 1 & \frac{1}{2} & -\frac{5}{2} \end{bmatrix}^{-1} \begin{bmatrix} -2 & -\frac{3}{2} & \frac{3}{2} \\ 1 & \frac{3}{2} & \frac{3}{2} \\ 1 & \frac{1}{2} & -\frac{5}{2} \end{bmatrix} \begin{bmatrix} -2 & -\frac{3}{2} & \frac{3}{2} \\ 1 & \frac{3}{2} & \frac{3}{2} \\ 1 & \frac{1}{2} & -\frac{5}{2} \end{bmatrix}$$
$$= \begin{bmatrix} -2 & -\frac{3}{2} & \frac{3}{2} \\ 1 & \frac{3}{2} & \frac{3}{2} \\ 1 & \frac{1}{2} & -\frac{5}{2} \end{bmatrix} = X$$

APPLICATION OF LINEAR TRANSFORMATION IN DEFORMATION MEASUREMENT

Digital camera belongs to the non-metric camera. It has no fiducial mark and orientation equipment; when it goes on field photography can not make camera horizontally, therefore the initial inner and outer orientation elements of value can not be obtained when the camera at the moment of photography. So the past commonly used method is no longer applicable, we must adopt new data processing method [5].

In this study using the direct linear transformation (DLT) method, the method doesn't need fiducial mark and the initial inner and outer orientation elements of value. Therefore this method is suitable for industrial and civil Photogrametry. The principle is

$$\begin{aligned} &x-(L_1X+L_2Y+L_3Z+L_4)/(L_9X+L_{10}Y+L_{11}Z+1)=0 \\ &z-(L_5X+L_6Y+L_7Z+L_8)/(L_9X+L_{10}Y+L_{11}Z+1)=0 \end{aligned} \tag{4}$$

Considering the effects of camera lens distortion measurement of non quantity, in the formula (4) is introduced corresponding correction terms $\Delta x, \Delta z$.

$$\Delta x=(x-x_0)r^2K_1$$
$$\Delta z=(z-z_0)r^2K_1$$

Obtained

$$\begin{aligned} &x+(x-x_0)r^2K_1-(L_1X+L_2Y+L_3Z+L_4)/(L_9X+L_{10}Y+L_{11}Z+1)=0 \\ &z+(z-z_0)r^2K_1-(L_5X+L_6Y+L_7Z+L_8)/(L_9X+L_{10}Y+L_{11}Z+1)=0 \end{aligned} \tag{5}$$

Among them K_1 is the coefficient symmetry lens distortion, x_0, z_0 is the main points of the image coordinatograph coordinates. The image diameters is

$$r=\left[(x-x_0)^2+(z-z_0)^2\right]^{\frac{1}{2}}$$

Inverse calculating the principal point coordinates of image

$$\begin{aligned} &x_0=(L_1L_9+L_2L_{10}+L_3L_{11})/(L_29+L_210+L_211) \\ &z_0=(L_5L_9+L_6L_{10}+L_7L_{11})/(L_29+L_210+L_211) \end{aligned} \tag{6}$$

Inverse calculating the principal distance of photograph

$$\begin{aligned} &F_x^2=-x_0{}^2+(L_1{}^2+L_2{}^2+L_3{}^2)/(L_9{}^2+L_{10}{}^2+L_{11}{}^2) \\ &F_z^2=-z_0{}^2+(L_5{}^2+L_6{}^2+L_7{}^2)/(L_9{}^2+L_{10}{}^2+L_{11}{}^2) \end{aligned} \tag{7}$$

Among them

$$F = \left(F_x + F_z\right)/2$$

Direct linear transformation formula is a set of nonlinear equations; it is calculated with the method of least squares iterative method. The algorithm consists of two steps,

$$\begin{aligned}(x+V_x)*(L_9X+L_{10}Y+L_{11}Z+1)-(L_1X+L_2Y+L_3Z+L_4)=0\\(z+V_z)*(L_9X+L_{10}Y+L_{11}Z+1)-(L_5X+L_6Y+L_7Z+L_8)=0\end{aligned} \tag{8}$$

The error equation of positive operator

$$\begin{bmatrix}Vx\\Vz\end{bmatrix}=$$

$$\frac{1}{A}*\begin{bmatrix}X & Y & Z & 1 & 0 & 0 & 0 & 0 & -xX & -xY & -xZ & -A(x-x_0)r^2\\0 & 0 & 0 & 0 & X & Y & Z & 1 & -zX & -zY & -zZ & -A(z-z_0)r^2\end{bmatrix}*\begin{bmatrix}L_1\\L_2\\\vdots\\L_{11}\\K_1\end{bmatrix}-\frac{1}{A}*\begin{bmatrix}X\\Z\end{bmatrix} \tag{9}$$

By (9) can be calculated for 11 L coefficients and a distortion coefficient K_1, the above formula written as

$$V = B*L-W$$

The Method equation is

$$B^T*B*L-B^T*W=0$$

The solution is

$$L=\left(L_1,L_2,\cdots,L_{11},K_1\right)^T=\left(B^T*B\right)-B^T*W \tag{10}$$

This operation step is an iterative process; the difference of two adjacent operations is less than 0.01mm as a limit cycle iterative solution method. Coefficient of each A is calculated by L value. And once again put the coefficient of A into the error equation, calculation of L coefficient, so the cycle until less than setting limits 0.01mm [6].

When was solved, we can obtain the coordinatograph coordinates,

$$\begin{aligned}x+\Delta x = x+(x-x_0)*r^2*K_1\\z+\Delta z = z+(z-z_0)*r^2*K_1\end{aligned} \tag{11}$$

Because each photograph has respective coefficient L, the process of positive operator should be carried out with piecewise.

$$\begin{bmatrix}Vx\\Vz\end{bmatrix}=\frac{1}{A}*\begin{bmatrix}L_1-xL_9 & L_2-xL_{10} & L_3-xL_{11}\\L_5-zL_9 & L_6-zL_{10} & L_7-zL_{11}\end{bmatrix}\times\begin{bmatrix}X\\Y\\Z\end{bmatrix}-\frac{1}{A}*\begin{bmatrix}x-L_4\\z-L_8\end{bmatrix} \tag{12}$$

For each photograph of each image point can have type (12), In order to obtain the X,Y,Z, at least two photograph. The formula is

$$V=N\times S-Q$$

The Method equation is

$$N^T\times N\times S-N^T\times Q=0$$

The solution is

$$S = \left(X * Y * Z\right)^{T} = \left(N^{T} * N\right)^{-1} * N^{T} * Q \tag{13}$$

The above calculations take the point by point manner, to accelerate the computation speed, reducing the occupied memory capacity [7].

CONCLUSION

This paper introduces the concept, basic knowledge and correlation theory of linear and linear transformation matrix, and given many numerical examples, embodies the importance of linear transformation thought in numerical calculation. Finally introduces linear transform in the application of deformation measurement.

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