P2P Tools

Coordinate Transformation – XYT Tool

User’s Manual

Version 1.50

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A topographic surface can be rotated to generate surfaces with various slopes. The derived sloping surfaces benefit the investigation of the slope effects in hydrotopographic analyses. This coordinate transformation program (XYT) is designed to calculate the coordinates of the new sloping surfaces and obtain their DEMs. The computation of the new coordinates (*X*, *Y*, and *Z*) is based on the Euler equation (Arfken and Weber, 2005).

1. Methodology

The rotation process can be accomplished by multiplying the DEM matrix of the original surface by rotational matrices for rotations about the *X*, *Y*, and *Z* axes. These three rotational matrices are composed of *sin* and *cos* functions of the user-specified rotation angles and can be respectively given by (Arfken and Weber, 2005):

$$\mathbf{R_X} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\beta_1 & \sin\beta_1 \\ 0 & -\sin\beta_1 & \cos\beta_1 \end{bmatrix} \tag{1}$$

$$\mathbf{R_Y} = \begin{bmatrix} \cos\beta_2 & 0 & \sin\beta_2 \\ 0 & 1 & 0 \\ -\sin\beta_2 & 0 & \cos\beta_2 \end{bmatrix} \tag{2}$$

$$\mathbf{R_Z} = \begin{bmatrix} \cos\beta_3 & \sin\beta_3 & 0 \\ -\sin\beta_3 & \cos\beta_3 & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{3}$$

where $\mathbf{R_x}$, $\mathbf{R_y}$, and $\mathbf{R_z}$ are the rotational matrices for rotations about the *X*, *Y*, and *Z* axes, respectively; and β_1, β_2, and β_3 are the rotation angles along the *X*, *Y*, and *Z* axes, respectively. In the program, any sloping surface is generated by rotating the original surface sequentially along the *X*, *Y*, and *Z* axes with angles of β_1, β_2, and β_3, respectively. The DEM matrix of the final rotated surface can be expressed as:

$$\mathbf{P}''' = \mathbf{P}\mathbf{R}_x\mathbf{R}_y\mathbf{R}_z = \mathbf{P}'\mathbf{R}_y\mathbf{R}_z = \mathbf{P}''\mathbf{R}_z \tag{4}$$

in which

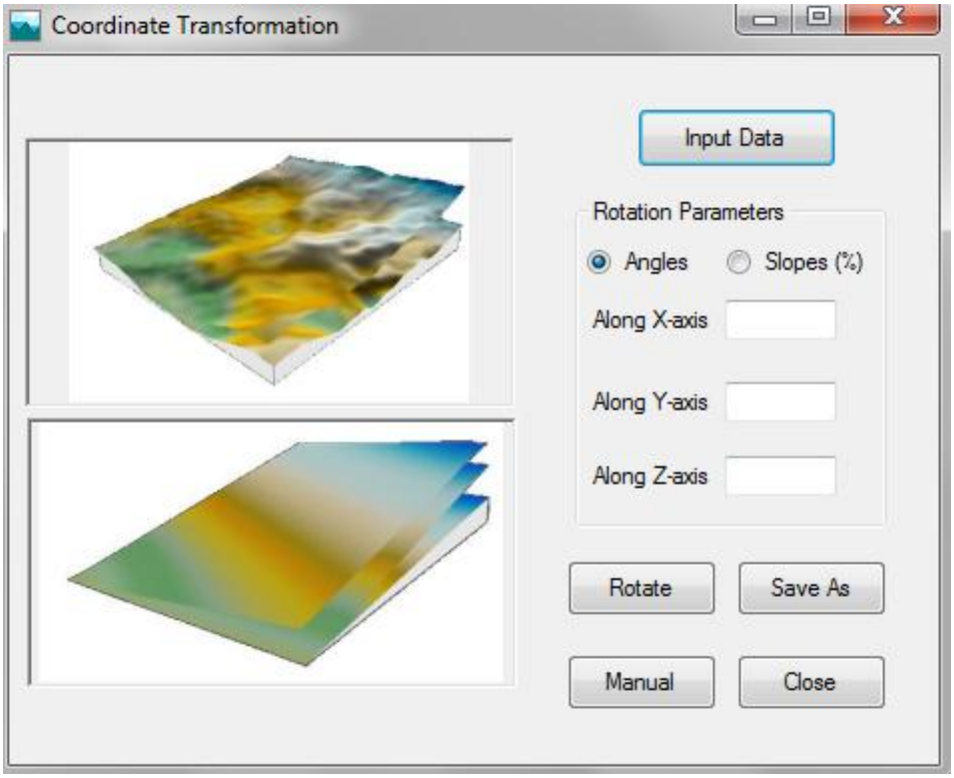
$$\mathbf{P}' = \begin{bmatrix} x_1' & y_1' & z_1' \\ x_2' & y_2' & z_2' \\ \cdots & \cdots & \cdots \\ x_n' & y_n' & z_n' \end{bmatrix} = \mathbf{PR}_x = \begin{bmatrix} x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ \cdots & \cdots & \cdots \\ x_n & y_n & z_n \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\beta_1 & \sin\beta_1 \\ 0 & -\sin\beta_1 & \cos\beta_1 \end{bmatrix} \tag{5}$$

$$\mathbf{P}'' = \begin{bmatrix} x_1'' & y_1'' & z_1'' \\ x_2'' & y_2'' & z_2'' \\ \cdots & \cdots & \cdots \\ x_n'' & y_n'' & z_n'' \end{bmatrix} = \mathbf{P}'\mathbf{R}_y = \begin{bmatrix} x_1' & y_1' & z_1' \\ x_2' & y_2' & z_2' \\ \cdots & \cdots & \cdots \\ x_n' & y_n' & z_n' \end{bmatrix} \begin{bmatrix} \cos\beta_2 & 0 & \sin\beta_2 \\ 0 & 1 & 0 \\ -\sin\beta_2 & 0 & \cos\beta_2 \end{bmatrix} \tag{6}$$

$$\mathbf{P}''' = \begin{bmatrix} x_1''' & y_1''' & z_1''' \\ x_2''' & y_2''' & z_2''' \\ \cdots & \cdots & \cdots \\ x_n''' & y_n''' & z_n''' \end{bmatrix} = \mathbf{P}''\mathbf{R}_z = \begin{bmatrix} x_1'' & y_1'' & z_1'' \\ x_2'' & y_2'' & z_2'' \\ \cdots & \cdots & \cdots \\ x_n'' & y_n'' & z_n'' \end{bmatrix} \begin{bmatrix} \cos\beta_3 & \sin\beta_3 & 0 \\ -\sin\beta_3 & \cos\beta_3 & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{7}$$

where **P** is the original DEM matrix; and **P′**, **P″**, and **P‴** are the DEM matrices after sequential rotations about the *X*, *Y* and *Z* axes with angles of β_1, β_2, and β_3, respectively.

2. Windows Interface



3. Procedures

1) Input data: By clicking the button "Input Data," users can load the original surface DEM data. The data requires three columns in the order of X, Y, and Z.
2) Rotation parameters: The original surface can be rotated based on either an angle or a slope, which can be selected by checking the option button "Angles" or "Slopes (%)." Then, users need to input the desired angles or slopes along the X, Y, and Z axes. Note that the angles or slopes can be zero.
3) Rotation: Click the button "Rotate" to execute the surface coordinate transformation program.
4) Results: The new transformed data can be saved to a file in a user specified directory by clicking the button "Save As."

Reference:

Arfken, G. B., and Weber, H. J. (2005). *Mathematical Methods for Physicists*. Elsevier Academic Press, San Diego. p199-203.