A fast 3D gravity forward algorithm based on cyclic convolution

Code By: Xianzhe Yin, Changli Yao, Yuanman Zheng, Guangxi Chen, Wenqiang Xu

School of Geophysics and Information Technology, China University of Geosciences, Beijing, China: 100083

E-mail: yinxz@cugb.edu.cn

clyao@cugb.edu.cn

The code is written in Matlab R2022a. The NED (North-East-Downward) coordinate system as positive x, y, and z directions is picked. Pseudo-code for novel spatial domain convolution fast forward modeling algorithm is shown following.

Algorithm: ***G*** = Graconvel (***Density***, ***r***, ***dr***, ***t***)

Fast calculation of gravity field for 3D density models

Input :

Density **:** Model density matrix;
r **:** Relative distance between model and grid;
dr **:** Size of the sub-cell model in x,y,z direction, respectively;
t **:** The number of points in x,y,z direction,respectively.

Output :

G **:** Gravity field of models.

```
Function G = Graconvel ( Density, r, dr, t )
    // Obtain the coordinate information of the field source and the measurement network.
    [ sN, sE, sZ ] = size ( Density );
    dE = dr (1) , dN = dr (2) , dZ = dr (3) ;
    rE = r (1) , rN = r (2) , rZ = r (3) ;
    tN = t (1) , tN = t (2) , tZ = t (3) ;
    x = [ 0 : tN - 1, -sN + 1 : -1 ] * dN - rN ;
    y = [ 0 : tE - 1, -sE + 1 : -1 ] * dE - rE ;
    z = [ 0 : tZ - 1, -sZ + 1 : -1 ] * dZ - rZ ;
    // Constructing new kernel function matrix.
    [ E, N, Z ] = meshgrid ( y, x, z ) ;
    // Use Formula (4)
    K = GaltranGra ( N, E, Z, 0, 0, 0, dN, dE, dZ ) ;
    // Build new field source
    Densitynew = zeros ( size ( N ) ) ;
    Densitynew( 1:sN, 1:sE, 1:sZ ) = Density ;
    // Convolution into frequency-domain dot product
    T = ifftn ( fftn ( Densitynew) .* fftn ( K ) ) ;
    // Intercept and obtain the gravity at grid
    G = T ( 1 : tN, 1 : tE, 1 : tZ ) ;
    return G ;
end
```

Code Description

1、Our methond

Fast computation of gravity field based on circular convolution.

Main function:

Cal_ModelGravityinFourie.m

Calling sub-functions:

- *Cal_tranGraf.m : Analytic formula method for calculating the gravity of a cube*
- *GraconvelP.m : Construct the circular kernel matrix and calculate the gravity field using FFT algorithm*

2、In space domain

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Cal_ModelGravityinFourie.m

Calling sub-functions:

- *Cal_tranGraf.m : Analytic formula method for calculating the gravity of a cube*

✧ ***Note: See code comments for detailed parameters.***