Asteroid Density

Short description
Estimate asteroid density distribution

`LSB_Density_Estimation` estimates the asteroid density distribution from that asteroid shape model, gravity field, mass, and spin state. Satisfies ALG-RS-013

`ComputePolyhedralCS_mex` and `ComputePolyhedralCSBar_mex` are helper functions that determine the spherical harmonics (unnormalized and normalize, respectively) associated with a polyhedral region of a shape model.

`ComputeWeightDensity` is a helper function that computes a weighting matrix for the spherical harmonics estimation based on the Kaula's rule of degree variance.

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Change History
V 1.0 Initial algorithm coded by Yu Takahashi
V 2.0 Initial SPOC entry TBD

Detailed Description including error handling
Algorithms for this approach are still being developed, although some already exist in the literature. The current methodology is based on the theory described in:
Y. Takahashi and D.J. Scheeres. "Small Body Surface Gravity Field Estimation from Orbit Determination," invited paper presented at the 34th Annual AAS GN&C Conference, Breckenridge, Colorado, February 2011. Paper AAS-11-053.

The program is run in Matlab. The *_mex helper functions are mex functions written in C, but compiled in Matlab.

This algorithm takes a shape model and an assumed density distribution (regions of the shape with constant density), and fits the densities so as to best reproduce the gravity field spherical harmonics in a least squares sense. The density distribution is not known, and is also not unique in terms of producing the gravity field, therefore there may be multiple density distributions of equal validity. This algorithm can estimate the density for a wide variety of density distributions.

Error codes will be reported. Error codes are TBD.

An alternative approach which may be used (instead or concurrently) is detailed in:
D.J. Scheeres, B. Khushalani and R.A. Werner. 2000. "Estimating Asteroid Density Distributions from Shape and Gravity Information," Planetary and Space Science 48: 965–971.

Parameters
Input Parameters

- init : initial settings
- M : Total mass of the asteroid, [kg]
- CS_Truth : Base model spherical harmonics, [n.d.]
- Polygon : Shape model settings
- Divided : Density distribution settings

Output Parameters

- rho : Estimated densities for each group in a relative sense [num_group x 1], [kg/km^3]
- rho_Actual : Estimated densities for each group in an absolute sense
- rho_Covariance : Covariance of the estimated densities [num_group x num_group], [kg/km^3]
- Mass_LSB : Total mass of the body as computed by the estimated densities

Example call
[rho_LSB, rho_Actual_LSB, rho_Covariance, Mass_LSB] = LSB_Density_Estimation(init, M, CS_Truth, Polygon, Divided);