FFT BASED ALGORITHM FOR EFFICIENT GRAVITY FIELD CALCULATION: COMPARISON WITH EXACT RESULTS FOR POLYHEDRAL SHAPE MODELS

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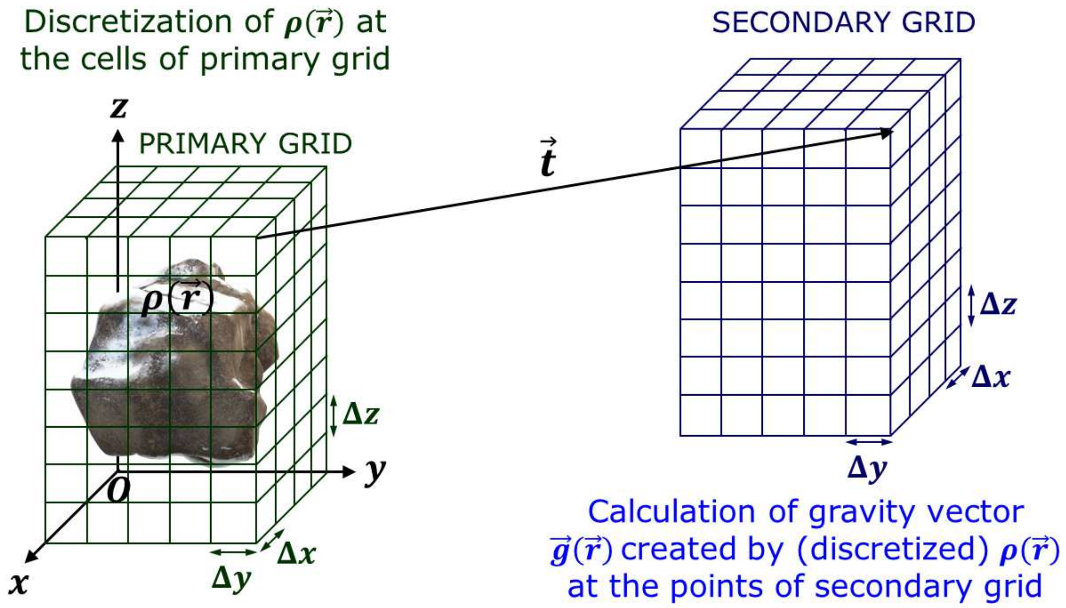
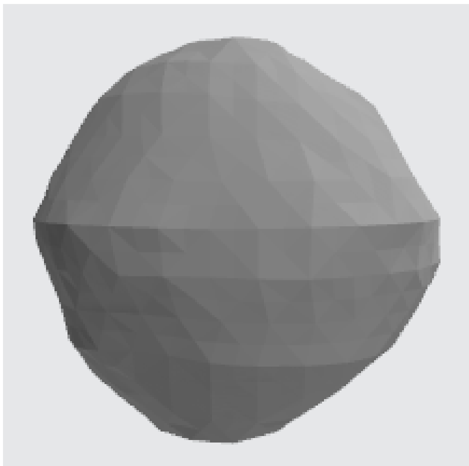
In the frame of the H2020 NEO-MAPP project [1,2], we propose a Fast Fourier Transform (FFT) [3] based algorithm for efficient computation of the gravity field created by a body with any arbitrary mass distribution. Our algorithm first considers a primary three-dimensional cartesian grid that contains the considered mass distribution and has uniform point spacings $\Delta x, \Delta y, \Delta z$. The density $\rho(\boldsymbol{r})$ of the body is then discretized at each primary grid cell. Next, our algorithm considers a secondary three-dimensional cartesian grid that applies an arbitrary translation $\vec{t}$ to the primary one and represents the space region where the gravity field will be computed. Finally, our algorithm computes efficiently the gravity vector $\vec{g}(\boldsymbol{r})$ created by the (discretized) body within the primary grid at all secondary grid points.

Outline of the proposed FFT based algorithm for efficient gravity field calculation

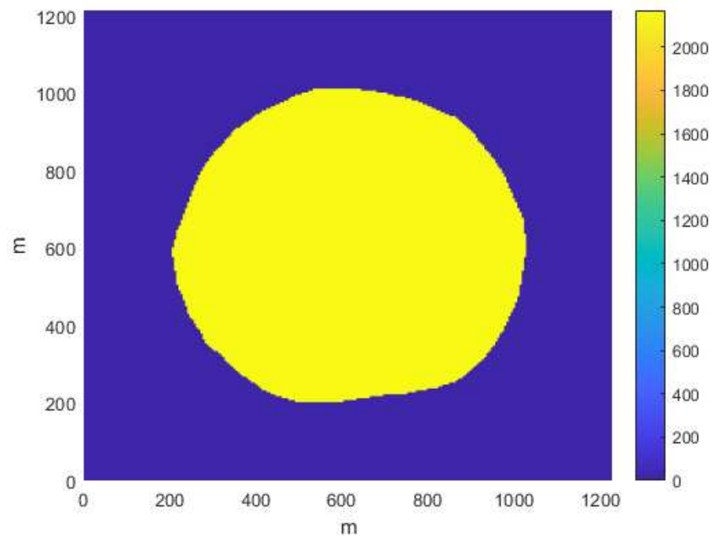


Didymos (65803) homogeneous polyhedral shape model



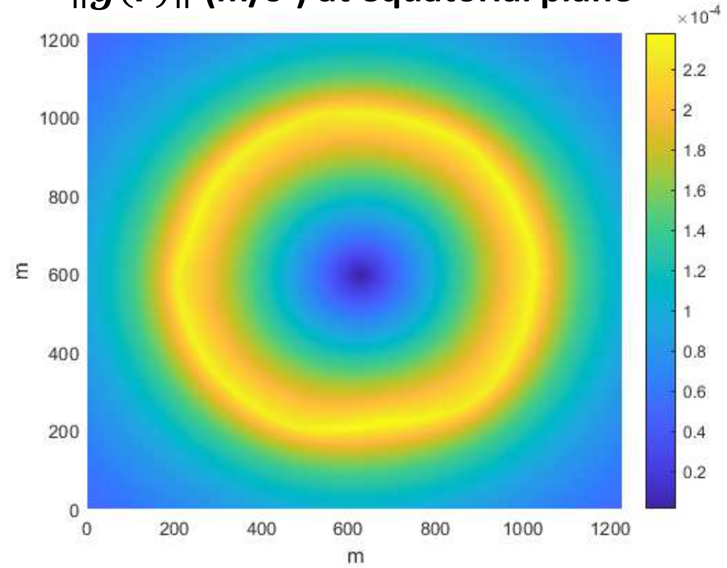
1996 triangular facets. Bulk density $\rho = 2170$ kg/m³

Discretized $\rho(r)$ (kg/m³) at equatorial plane



$(\Delta x, \Delta y, \Delta z) = (5.11, 5.06, 4.96)$ m

$\|\vec{g}(r)\|$ (m/s²) at equatorial plane

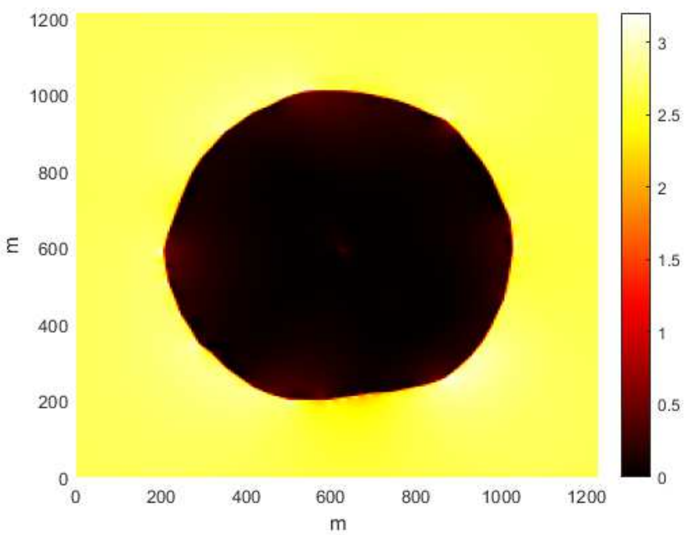


241 points/axis (~14·10⁶ points), $\vec{t} = \vec{0}$

Calculation of $\vec{g}(r)$ in 60 s (16 GB RAM)

Discretization error **→ Mass of *discretized* body with bulk density ρ is the actual body mass multiplied by a factor $f = 1.0264$**

Relative error (%) of $\|\vec{g}(r)\|$ respect to exact gravity field modulus [4]



maximum error of 3.2 % outside the body but *negligible error inside* the body.

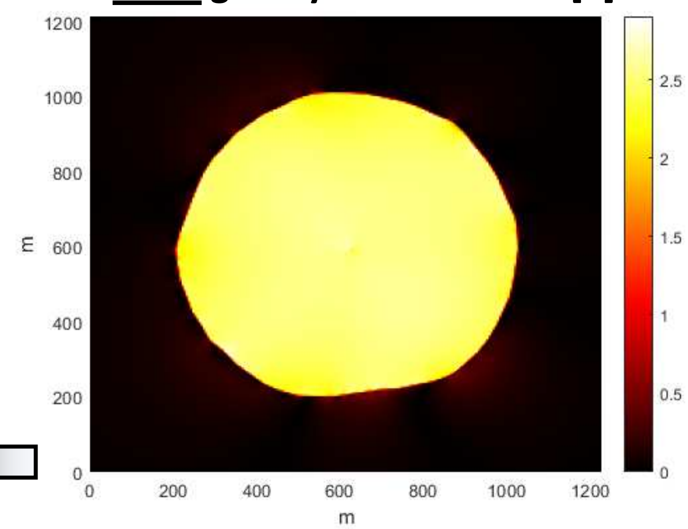
ACCURATE GRAVITY FIELD *INSIDE* THE BODY

$\vec{g}(r)$ AND $f^{-1}\vec{g}(r)$ JOINTLY ALLOW TO DETERMINE ACCURATELY THE GRAVITY FIELD INSIDE AND OUTSIDE THE BODY

maximum error of 2.9 % inside the body but *negligible error outside* the body.

ACCURATE GRAVITY FIELD *OUTSIDE* THE BODY

Relative error (%) of $\|f^{-1}\vec{g}(r)\|$ respect to exact gravity field modulus [4]



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