Adaptive-Picard-Chebyshev for Propagating Perturbed Two-Body Orbits

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Overview

This algorithm propagates orbits in the perturbed two-body environment using automated and adaptive tuning of segments and Chebyshev polynomial degree. The code has the following capability:

1. Automated segmentation & polynomial degree scheme
2. Loads precomputed matrices for desired N
3. Warm & Hot starts
4. Radially adaptive gravity
5. Variable fidelity force model
6. Quasilinearization error feedback
7. Reosculate Keplerian perigee after each orbit
8. Interpolation

A test case is presented the demonstrates how the algorithm is run. Edit ***test.c*** to set different initial conditions, propagation time and spherical harmonic gravity degree.

Compile & Run

1. Compile the matrix builder from within /src
   >> make matrix_builder
2. Perform the one time build of the constant Picard-Chebyshev matrices from within /src
   >> ./matrix_builder
3. Compile the propagator from within /src
   >> make
4. Propagate the test case orbit from within /src
   >> ./test

Functions

\src

adaptive_picard_chebyshev.c
This is the where all operations take place for performing the numerical integration.

c_functions.c
Performs some simple vector-matrix operations.

chebyshev.c
Generates Chebyshev polynomials of the first kind.

clenshaw_curtis_II.c
Generates constant matrices for second order Clenshaw-Curtis Quadrature.

ecef2eci.c
Converts states from the body frame to the inertial frame.

eci2ecef.c
Converts states from the inertial frame to the body frame.

EGM2008.c
Computes the spherical harmonic gravity for a specified degree and order.

FandG.c
Computes the analytical solution to the two-body problem in celestial mechanics.

Interpolate.c
Interpolates the solution to output intervals (ephemeris) specified by the user.

lsq_chebyshev_fit.c
Builds least squares operator and Chebyshev matrix.

makefile
File to compile all the code.

matrix_builder.c
One time build & store constant matrices required for the Adaptive Picard-Chebyshev numerical integration method.

matrix_loader.c
Loads constant matrices required for the Adaptive Picard-Chebyshev numerical integration method.

perigee_approx.c
Computes the approximate Keplerian perigee in the function ***polydegree_segments.c*** if the starting user specified initial conditions do not correspond to perigee. This is required for computing the first Keplerian orbit which is used to determine the number of segments and nodes that will produce a solution that satisfies the user desired tolerance.

perturbed_gravity.c
Computes gravity using the terminal convergence approximations which greatly enhances the efficiency of the algorithm.

picard_chebyshev_propagator.c
Propagates segment by segment from t0 through to tf.

picard_error_feedback.c
Computes the linear error correction term that accelerates Picard iteration.

picard_iteration.c
Iterates one segment at a time until convergence.

polydegree_segments.c
Computes the number of segments per orbit and the degree of the Chebyshev polynomial required to fit acceleration to the user desired precision.

prepare_propagator.c
Loads matrices for the correct polynomial degree and computes the start and send times for each segment.

radial_gravity.c
Computes the required gravity degree based on the distance from the surface of the Earth.

reosc_perigee.c
Reosculates Keplerian perigee at the end of each orbit.

rv2elm.c
Converts Cartesian to Keplerian orbit elements.

test.c
Sets up a test case and runs ***adaptive_picard_chebyshev***.

\inc

This folder contains all the header files corresponding to the .c sourse files in the \src folder. In addition, const.h is also located in this folder. Const.h specifies a number of astrodynamics constants.

\matrices

This folder stores the Picard-Chebyshev matrix binary files after the matrix_builder command is run.