

KG++: SOFTWARE FOR PROCESSING SATELLITE LASER RANGING OBSERVATIONS

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ABSTRACT. The software KG++ for processing satellite laser ranging observations is presented. The software architecture, methodology with respect to utilization of models, ordinal differential equations (ODE) integrating procedure and test results are shown and analyzed. The implementation of IERS standard models into the system is demonstrated. The software will be used in the Ukrainian center of Satellite Laser Ranging (SLR) data analysis.

1. INTRODUCTION

The Earth as a planet is characterized by a set of dynamic and geodetic parameters: radius, mass, instantaneous rotation axis, rotation speed, geopotential coefficients, nutation parameters, Love and Shida numbers, etc. To observe and deduce them, different geophysical and astronomical methods are used. Until the end of the seventies the only method applicable for that purpose was astrometric observation of the stars. In the last 40 years new methods, including Very Long Baseline Interferometry (VLBI) of distant radio sources, radio observations of Navigation Satellites, and Satellite Laser Ranging have become available. The latter one is the oldest among these methods - SLR has been used from 1976 until now. The method consists in measuring the distance between terrestrial stations and specially-designed satellites. The distance may be measured with cm precision. If one collects a sufficient amount of observations, any of the listed Earth parameters may be deduced.

The KyivGeodynamics software was created at the Space Geodynamics department of Main Astronomical Observatory (MAO, Kyiv, Ukraine) in the early eighties. Written in an old version of Fortran it is mostly outdated now. The algorithms included in this original software are no more used by the geospatial community and need to be rewritten.

The current version (KG++) isn't a revitalized form of the old KyivGeodynamics, which was used for processing SLR data by the Ukrainian Data Analysis Centre from the time of the MERIT (Measuring of Earth Rotation and Intercomparing of Techniques) project. KG++ is written in C++ from scratch incorporating modern software developing technologies. It uses a plugin approach and it is automatized as much as possible.

The application is cross-platform (tested under Windows XP, Linux-Suse and Mac OS X). It uses its native DBMS (Database Management System) engine which is designed to hold normal points and full-rate SLR data. Simultaneous processing of the data from multiple satellites is possible. Manipulation with different force and transformation models, used in the equation of satellite motion is very user-friendly and intuitive.

2. METHOD

Let us denote with \vec{R} the station geocentric position while \vec{r} represents the satellite geocentric position. The vector between station and satellite reads

$$\vec{\rho} = \vec{r} - \vec{R}. \quad (1)$$

It is convenient to write down \vec{R} in the Earth-based reference frame, but \vec{r} in the space-referred one.

If the transformation matrix between them is denoted as \mathbb{Q} , then

$$\vec{\rho} = \vec{r} - \mathbb{Q}\vec{R}. \quad (2)$$

The transformation matrix comprises the position of the instantaneous rotation axis, nutation parameters, tectonics model, etc.

The satellite position \vec{r} is found by integration of the corresponding equation of motion:

$$\frac{d^2\vec{r}}{dt^2} = \vec{F}_{geo} + \vec{F}_{light} + \vec{F}_{planets} + \vec{F}_{others}, \quad (3)$$

where *geo* stands for Earth geopotential force, *light* for direct and indirect radiation pressure, *planets* for influence of Solar system bodies, etc.

The most modern algorithms for calculation of the forces and transformations entering Equations (2) and (3) are collected by the International Earth Rotation and Reference Systems Service in [IERS, 2010]. The calculations are done by cycling according to the scheme in Figure 1 (clockwise from box 1: observations collected by the ObsManager are put into the linear equation system together with the modeled values from the ModelManager and derivatives provided by the Derivator. ρ_o — *observed* distance, ρ_c — *calculated* distance, $\frac{\partial \rho_c}{\partial E_i}$ — derivatives of ρ_c with respect to the estimated parameters, ΔE_i — corrections to model parameters (to be solved for).

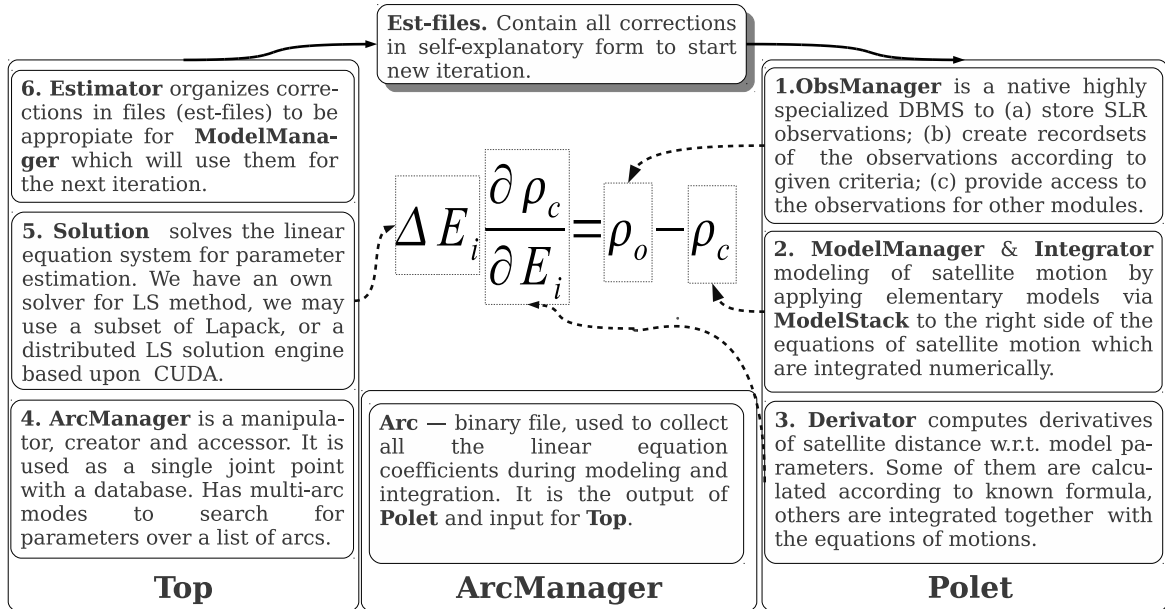


Figure 1: Flowchart of the KG++.

The software is based upon a component-oriented architecture, with wide usage of plugins (these are the lightweight software components designed for easy replacement and exchange). Different models are manipulated in the same way: to change the models, one should not recompile code, but instead change the line in the ini-file. The software may integrate many satellites at the same time [Taradiy, 1984], it has a user friendly interface and is well-documented. Serious efforts were made to make the software running under distributed computer environment: our integration subsystem may work under CUDA [Nvidia, 2007].

3. REFERENCES

- IERS, 2010, "IERS Standards 2010", IERS Conventions Center, 2011, 180 p.
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