JSatOrb: ISAE-Supaero's open-source software tool for teaching classical orbital calculations

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Abstract—JSatOrb is an ISAE-Supaero's software tool dedicated to orbital calculation and designed for pedagogical purposes, with professional level features outputs. It has been initiated to find a soft which would fill the gap between local teachers developed tools and professional tools, exploiting state of the arts algorithms concerning space mechanics calculus. Even if current provided open source libraries are not fully compliant with our pedagogical requirements (simplicity, flexibility, multi-platform and ergonomics), they provide complete and accurate calculus methods that are dedicated to a professional use. However, GUI part is not the main concern when used by space engineers which only require API access.

Concretely, JSatorb project is open-source (MIT license) and under development. It is inspired from current full-stack implementation methods. Ergonomic and intuitivity are at stack concerning the front-end, which is mainly based on Angular (https://angular.io/) and Cesium (cesiumjs.org). Efficiency and correctness on calculus are provided by the back-end part, which relies on Orekit (https://www.orekit.org/). Developed in Java, Orekit is a space dynamics open source library. It depends only on the Java Standard Edition version 8 and Hipparchus (https://hipparchus.org/) version 1.0 libraries at runtime. It is widely used by ESA and CNES.

CONTENTS

I. INTRODUCTION

Historically ISAE-SUPAERO developed a software tool dedicated to orbital calculation and designed for pedagogical purposes: Satorb. It has been widely used for more than fifteen years in teaching master level students. It was closed software, based on VB.NET (https://code.msdn. microsoft.com/Official-Visual-Studio-f48134ec). SatOrb was designed to easily set satellites in motion and analyse its effects, manoeuvres, ephemeris... JSatOrb can be seen as an evolution of Satorb, open-source and modernised.It designed to be ergonomic, easily understantable, intuitive as a student-focused learning tool. But it should be comparable to professional software for researchers and engineers.

It is inspired from current full-stack implementation methods. Ergonomic and intuitivity are at stack concerning the front-end, which is mainly based on Angular (https://angular. io/) and Cesium (cesiumjs.org). Efficiency and correctness on calculus are provided by the back-end part, which relies on Orekit (https://www.orekit.org/).

First of all, we describe main features implemented in original Satorb software (Section II). we looked in litterature if alternative exist (Section III-A) and which astrodynamics library could be used (Section III-B). The decision on how to handle the user interface has also been taken into account (Section III-D). Afterward, we propose an implementation closer to current web developpments (Section III-D), based on a front-end providing all functionnalities to the end-user, and a back-end handling all calculus to the astrodynamics library.

II. JSATORB SPECIFICATION: AS GOOD AS OUR CURRENT TEACHING TOOL, SATORB

SatOrb is an orbit and multi-satellite, multi-station mission analysis software that allows a 2D or 3D display of satellites and constellations as well as multiple analysis of access, visibility, coverage and reports on the radio links. SatOrb was developed by C. Colongo at ISAE-SUPAERO. Other institutions have contributed to the development such as the German university TU München. [18].

The main available features of this software are summed up in the following list:

1) Create satellites which can be given very specific energetic, orbital or behavioural parameters;

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inspired algorithms for solving specific hard optimization problems and finally to create awareness on these domains to a wider audience of practitioners SEMCCO 2010 received 225 paper submissions from 20 countries across the globe After a rigorous peer review process involving 610 reviews in total 90 fu length articles were accepted for oral presentation at the conference This corresponds to an acceptance rate of 40% and is intended for maintaining the high standards of the conference proceedings The papers included in this LNCS volume cover a wide range of topics in swarm evolutionary and memetic computing algorithms and their real world applications in problems selected from diverse domains of science and engineering **Computational Science - ICCS 2002** Peter M.A. Sloot,C.J. Kenneth Tan,Jack J. Dongarra,Alfons G. Hoekstra,2002-04-12 Computational Science is the scienti c discipline that aims at the development and understanding of new computational methods and techniques to model and simulate complex systems The area of application includes natural systems such as biology envir mental and geo sciences physics and chemistry and synthetic systems such as electronics and nancial and economic systems The discipline is a bridge b ween classical computer science logic complexity architecture algorithms mathematics and the use of computers in the aforementioned areas The relevance for society stems from the numerous challenges that exist in the various science and engineering disciplines which can be tackled by advances made in this eld For instance new models and methods to study environmental issues like the quality of air water and soil and weather and climate predictions through simulations as well as the simulation supported development of cars airplanes and medical and transport systems etc Paraphrasing R Kenway R D Kenway Contemporary Physics 1994 There is an important message to scientists politicians and industrialists in the future science the best industrial design and manufacture the greatest medical progress and the most accurate environmental monitoring and forecasting will be done by countries that most rapidly exploit the full potential ofcomputational science Nowadays we have access to high end computer architectures and a large range of computing environments mainly as a consequence of the enormous s mulus from the various international programs on advanced computing e g **Proceedings of Frontiers in Education 1996** IEEE, Education Society Staff,Ieee Education Society,1996-11 MAA Notes ,1983 Proceedings American Society for Engineering Education,1995 **Real-time Systems Education II** University of Pittsburgh,1997 **Real-time Systems Education** ,1997 Dr. Dobb's Journal of Software Tools for the Professional Programmer ,1987 **Advances in Control Education 1994** A. Ichikawa,K. Furuta,2014-05-23 The implementation of effective control systems can help to achieve a wide range of benefits not least in terms of real cost savings Education plays a vital role in ensuring continued success and its importance is well recognized by IFAC with a specifically designated technical committee in this area This invaluable publication brings together the results of international research and experience in the latest control education techniques as presented at the most recent symposium Information on course curricula is presented as well as teachware including software and laboratory experimental appparatus CALISCE '91 Eddy N. Forte,1991 Song Sheets to Software Elizabeth C. Axford,2004-06-24

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