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Editorial Reproducibility of Computational Models

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Abstract

Here we describe Tellurium, a Python based platform for supporting the development of reproducible models in systems biology. The tool exploits a number of available standards, including SBML, SED-ML and COMBINE archives to achieve its goal.

I. INTRODUCTION

The scientific method relies on the reproducibility of experimental and computational results. That is the ability of a third-party to reproduce the results of an inquiry by using different equipment, different software and different materials. Unfortunately, there is a growing concern that biomedical research is increasingly difficult to reproduce, and that this is hindering scientific progress [1]. One might imagine that computational biology should be easy to reproduce because it is inherently digital. However, even here most computational biology research is not reproducible [2]. The reasons for the failure to reproduce computational models are many. These range from missing data, missing equations, errors in transcribing the equations to the published paper, and, in a number of cases, errors in the reported units. In addition, in a growing number of cases the original software that was used to carry out the analysis is no longer available or the source code that was used to run the analysis is closed. The question arises: how can we help researchers publish reproducible computational research?

II. TELLURIUM

Tellurium (tellurium.analogmachine.org) is a Python based integrated environment designed for model building, analysis, simulation and reproducibility in systems and synthetic biology. Tellurium is a modular, cross-platform, and open-source integrated development environment (IDE) composed of multiple libraries, plugins, and specialized modules and methods. Tellurium ensures exchangeability and reproducibility of computational models by supporting SBML (Systems Biology Markup Language), SED-ML (Simulation Experiment Description Markup Language), and the COMBINE archive [3,4,5]. Tellurium is a self-contained modeling platform which comes with a fully configured Python distribution independent of other local Python installations on the target machine. The main interface is based on the Spyder IDE which has a UI akin to MATLAB. Tellurium uses libRoadRunner [6] as the default simulation engine due to its superior performance. libRoadRunner supports

deterministic, stochastic and steady state analyses. To demonstrate reproducibility, we can use Tellurium to create a COMBINE archive.

We modify the archive and reload the result, demonstrating compliance. We start with the MAPK model described previously [7]. Using SED-ML, we define the simulation setup and the exact parameters used by the solver. We export the SBML and SED-ML components of the simulation to a COMBINE archive. Figure 1 illustrates the output of the re-imported model in Tellurium. The example illustrates how we can reproduce exactly the simulations described in the COMBINE archive.

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Figure 1:
Time course simulation of MAPK and bi-phosphorylated MAPK concentration reproduced from (A) the original COMBINE archive, and (B) the modified combine archive showing full reproducibility of the changed model.