Documentation of ESDC's Visualization System

Author: Themistoklis Spanoudis

A Brief Introduction

ESDC (Evolutionary System Design Converger) is a software suite designed for optimization of complex engineering systems. ESDC uses system modelling equations, a database containing data points of existing systems, system scaling equations as well as mission requirements to design systems that fulfill their design objectives in the most efficient and effective way. The heart of the optimization process is a genetic algorithm, which takes an initial population of design points and navigates the design space using a series of operations, such as mutation, that inspired from natural selection. One optimization cycle produces a lot of data and need to be analyzed and examined in order to acquire insight about the optimal designs, the performance of the algorithm and the design space in general. For this purpose, a flexible visualization system was developed for my GSoC 2019 project. The goal of this document is to introduce new users or developers in the topic and to demonstrate how the tool works.

GSoC Blog Posts

This visualization system was developed for my GSoC 2019 project. During that period, three blog posts were post at aerospaceresearch's website which document the progress of this project, explain the motivation behind this work and demonstrate potential use cases of the tool. For this reason, these blog posts are considered a valuable and essential asset of this documentation. If this is your first time using or learning about the tool, it is extremely recommended that you go through these posts first. They will provide great context about the optimization of engineering systems in general and the capabilities of ESDC's visualization system. You can find the blog posts in the following links.

Blog post 1: https://aerospaceresearch.net/?p=1542

Blog post 2: https://aerospaceresearch.net/?p=1571

Blog post 3: https://aerospaceresearch.net/?p=1785

Github Repository

As of writing this document, ESDC is hosted in aerospaceresearch's Github account. Here is the link: https://github.com/aerospaceresearch/ESDC

The codebase of the visualization system can be found under ESDC/Code/Output/Visualization path. Here is the link: https://github.com/aerospaceresearch/ESDC/tree/master/Code/Output/Visualization

High-Level Overview

The visualization system uses an XML input file to communicate with the user. Using this XML file, the user can define what type of visualizations he wants to have produced when the visualization system is invoked. Using all available fields in the XML file a user can customize and

fine tune the content, the graphic features as well as the appearance of the visualizations. A user can additionally provide the desired file formats in which the visualizations will be saved, and instruct the tool to generate gif animations of the optimization process. Thus, learning to use the visualization tool requires becoming familiar with the structure and the fields of the XML input file, which is what this documentation will focus on.

XML Input File Fields

<plot_case> is the outermost field that contains inside all subfields that specify the settings for one visualization. The XML can contain any number of plot case, that are executed by the visualization system.

Depending on the type of visualization (2d or 3d) the <plot_case> field contains the following subfields.

For 2d visualizations: <active>, <type>, <input_cases>, <save>, <animate_and_save>, <lineages>, <appearance>, <y>, <plot_line_active>, <line_type>, <line_color>, <marker_type>, <marker_color>, <subsystems_bars>, <seed_points>, <failed_mutations>

For 3d visualizations: all the subfields of the 2d plots, plus <x> and <z>

Most of these fields have additional nested fields which are grouped according to their use. Trying to list each field in this document along with a description of its expected input wouldn't be effective because the structure of the XML file (the way in which the fields all grouped) would be lost, which would take away an important part of the understanding. For this reason, two "documentation" XML input files have been created where you can find all fields nested appropriately, accompanied by a short description of the expected input of each field. You can find these XML files here:
https://github.com/aerospaceresearch/ESDC/tree/master/Documentation/Visualization/XML_fields_description

Sample Visualizations – XML Input Files

In order to provide an additional practical way of exploring the functionality of the visualization system, the XML input files that where used to generate some of visualizations and animations found in the blog post, are also provided. You can find them here:
https://github.com/aerospaceresearch/ESDC/tree/master/Documentation/Visualization/sample_visualizations

These XML input files can also be used as a template or starting point for generating your own visualizations and animations. In fact, I encourage you to play around with these files, change some options and discover the various capabilities of ESDC's visualization system.