Workflow-based Material Characterization for LS-DYNA® in d3VIEW

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Abstract

Characterization of material models involves a series of operations, verifications and eventual use of developed material card in simulation models. LS-DYNA presents over 300 material models and provides a wide-variety of materials that can be modeled. In this paper, we hope to present a workflow based material characterization in d3VIEW for Metals, Polymers, Cellular Solids, and Elastomers. A simple workflow example will be included to demonstrate the process of importing data from an Uni-Axial test, create a preliminary material card, run LS-DYNA simulations to optimize the post-necking behavior using LS-OPT®, and generation of the LS-DYNA keyword that incorporates parameters identified in LS-OPT. With the workflow capability, we hope to significantly reduce the time and effort involved in developing material cards for LS-DYNA.

Introduction

Material laws in LS-DYNA are based on in-variant system that allows characterization based on simple uni-axial tests in most cases and materials. If you consider metals, a uni-axial tensile test to extract the engineering stress-strain curve is sufficient to model the behavior in full-3d stress space. Similarly, for Elastomers, we could perform a uni-axial compression and tensile test on a specimen to determine force-deflection curve that can go directly into several of the material laws designed for modeling Elastomeric behavior.

Need for Workflow-based Characterization

In several materials models in LS-DYNA, the experimental data will need to be transformed in a sequence of steps, some iterative such as finding an optimal extrapolation constant in metals for post-necking stress profile, before they can be mapped to an individual parameters in an appropriate material keyword. These series of steps can be manual and be prone to human errors making it difficult to verify before using them in simulation models.

Workers and Workflow

Workflows have been in use in several applications and you probably have already used them, for example, while ordering a Pizza or ordering a product from an online merchandise. Our motivation is to develop a system in d3VIEW that can provide a *systematic* way of importing data from experimental labs and transform them so they can used to generate a working LS-DYNA keyword card that is verified.

In d3VIEW, Workflow is an application that allows a user to build, configure and execute workflows. Each workflow comprises of a series of 'Workers' that follow a single responsibility principle. For example, we have a 'Worker' named 'CurveDerive' who takes in a Curve as an input and provides a derivative of the Curve as its

output. This worker will not function if the input is not a curve and will always produce the same result given a Curve – that it is only is capable of computing a derivative of a given Curve. In d3VIEW, there 600+ workers, each capable of a single pre-defined task. Figure 1 shows different types of workers available in d3VIEW and that comes packaged and requires no scripting or additional effort to use them.
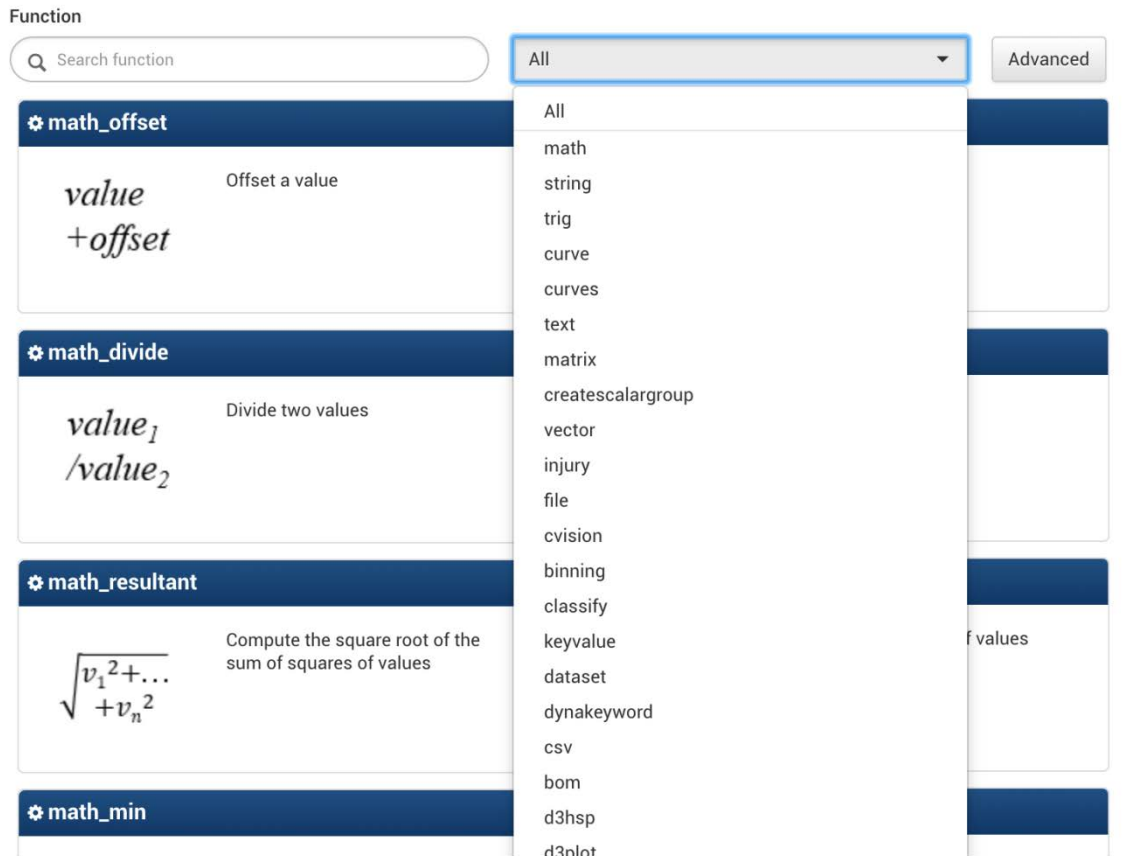

Figure 1. Available Workers in d3VIEW by category

Using these workers, that come pre-built in d3VIEW, we can define simple to complex workflows. Figure 2 shows a simple workflow that imports a curve from an Excel, computes its derivative, then passes its output to the next worker that is a decision worker. The decision worker evaluates the peak value of the curve and compared it with a input parameter and emits a TRUE/FALSE output. If the output is true, the curve is offset and if the output is false, the curve is scaled by a certain value.
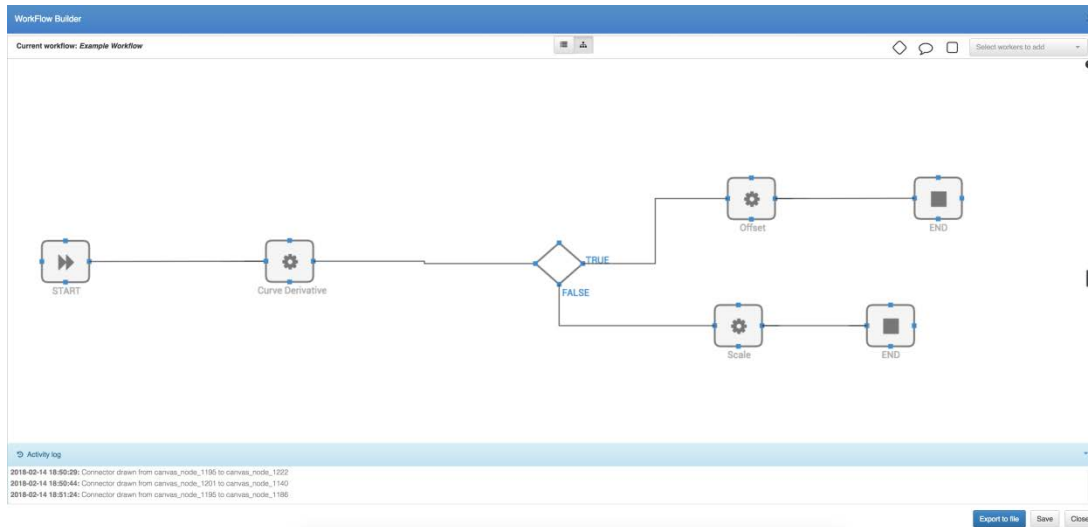
Figure 2. Simple Workflow to Compute a Derivative and Scale or Offset based on a Decision

Workflows in d3VIEW, can be created and shared with other users. Shared workflows can be either allowed to be modified or just be used. This allows an Engineer who is very familiar with material characterization to create a workflow and share with others for re-use.

Example Workflow for MAT_024 keyword creation

Demonstration of the workflow is planned during the paper presentation. The demonstration will use an Excel file that contains a uni-axial test to generate a valid LS-DYNA keyword card.

Summary

Workflows is an essential component in d3VIEW and we hope to simplify complex tasks by breaking them down into smaller components such as 'Workers' that is configurable and reproducible in its outcome.

References

LS-DYNA Keyword Manual
LS-DYNA Theory Manual