Using GenEx tool to extract histories/responses from data files

Problem description

- GenEx is an important output extraction tool of LS-OPT specifically for solvers other than LS-DYNA. This example demonstrates the use of GenEx for extracting histories and responses from data files.
- The pole-car crash design optimization example is modified by defining LS-DYNA histories and responses using GenEx tool. Even though Genex tool is not required for this example, it has been used only to demonstrate the use the Genex tool.
- This example is a minimization problem with total mass of four parts (part no.2, 3, 4, 5) as objective and intrusion distance calculated as difference between displacements of two nodes (432 and 167) is the design constraint.
- The steps to define task type and design parameters are similar to other simple LS-OPT examples. In this example, internal energy, nodal acceleration and rigid wall force are defined as histories with part masses and nodal displacements defined as responses using various features available within GenEx tool.

The following files are used in this example:

main.k	Main (root) file with LS-OPT design parameters
car5.k	Include file specified in main.k
rigid2	Include file specified in main.k
sample_nodout	Input data file for nodout histories/responses
sample_glstat	Input data file for glstat histories
sample_rwforc	Input data file for rwforc histories
sample_d3hsp	Input data file for d3hsp responses
genex_nodout	GenEx input file for nodout
genex_glstat	GenEx input file for glstat
genex_rwforc	GenEx input file for rwforc
genex_d3hsp	GenEx input file for d3hsp

Defining Responses in GenEx:

1. Open the file genex.start.lsopt using LS-OPT GUI.
2. The task, parameters, sampling and solver settings have already been defined in the example.
3. The next step is to define responses using GenEx so that these responses can be later assigned as optimization objectives or constraints.
4. Instead of choosing LS-DYNA responses, the responses are defined using GenEx tool i.e. using ‘GENEX’ option available under generic list of options within ‘Histories’ and ‘Responses’ tab of *Setup* dialog box. Defining histories/responses using GenEx requires an input data file and a .g6 genex file as shown in Figure 1.

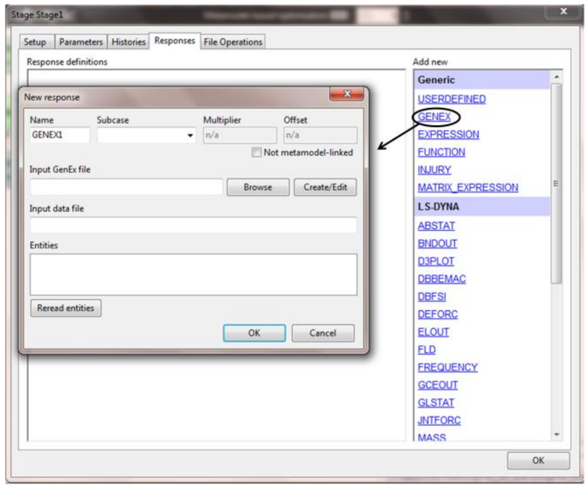

Figure 1: GenEx response dialog box

5. To define sum of part masses as objective, mass of each part should be defined separately as a response. Since the values are extracted from same data file (*d3hsp*), they can have same genex input file (.g6 file). The GenEx input file consists of information relative to locations of response values to be extracted from the data file.
6. To define mass of part 2 as a response, click on GENEX within *Responses* tab. Assign a name to the response and click on Create/Edit to open GenEx window for creating a .g6 file (GenEx input file).
7. The mass is extracted from *d3hsp* file of LS-DYNA, therefore open *sample_d3hsp* file in GenEx (File → Select input file). The sample files are output files of baseline analysis.
8. The mass of part 2 in *d3hsp* file is identified using anchors and entities. *Anchors* facilitate searching of a field from the data file and an *Entity* is the actual field of values that are to be extracted.
9. The part mass information is printed in *d3hsp* under 'summary of mass' section. To define an anchor, click on *New Anchor*, assign a name (e.g. mass_of_parts) and enter "summary of mass" in '*Text to search for'* field and hit enter. This creates an anchor at start of first occurrence of text "summary of mass" throughout d3hsp file as shown in figure 2.

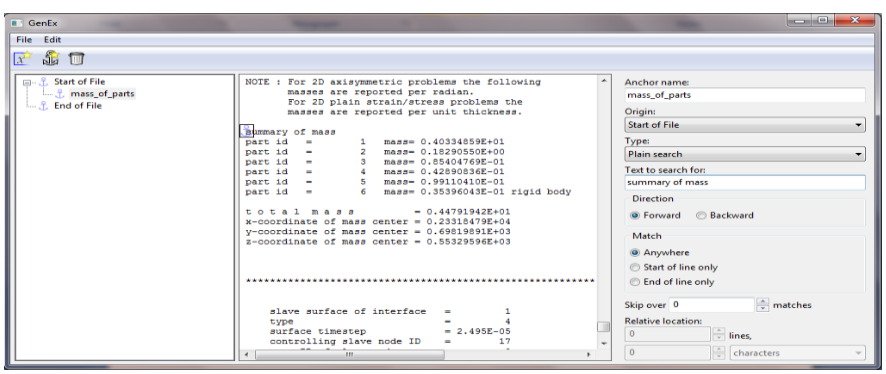

Figure 2: Creating Anchors in GenEx

10. Now an entity can be defined under this anchor using *New Entry* option. Since responses are scalar values, the '*Type of Entity'* is selected as '*Scalar*'. The relative location of this entity is adjusted to obtain the value of mass of part 2. For example, in the *sample_d3hsp* file, the relative location of mass of part 2 with respect to the defined anchor is given by 2nd line, 5th column. The final value to be extracted is highlighted on the data file as shown in figure 3.

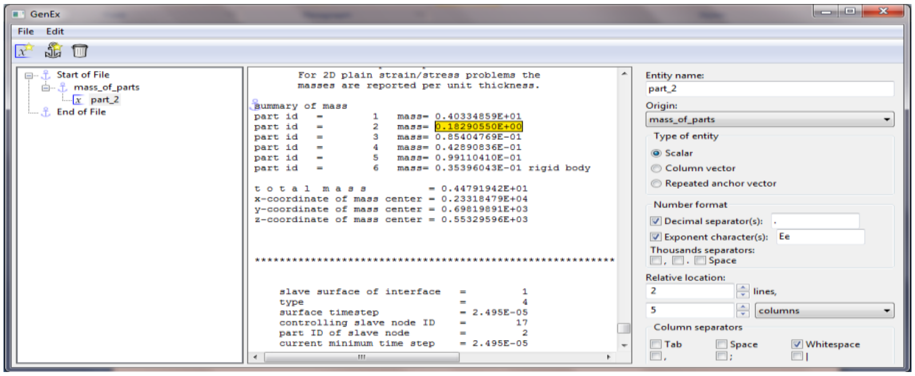

Figure 3: Entity selection in GenEx

11. Similarly, more entities can be created for other parts under the same anchor with only difference in their respective relative locations, figure 4.

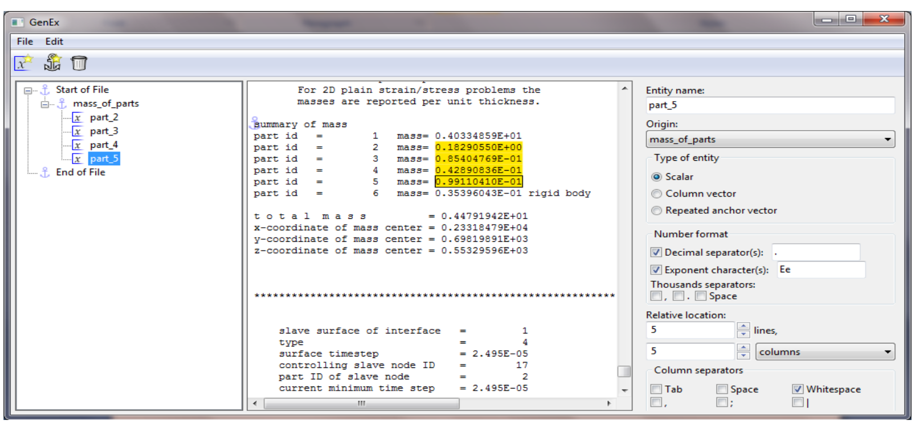

Figure 4: Multiple entities of an anchor in GenEx

12. Once all entities are defined, save the process to create a *.g6* file (*sample_d3hsp.g6*). Now LS-OPT responses can be defined using this *.g6* and corresponding data file. In *New Response* dialog box, select this *.g6* file as GenEx input file. Once this file is selected, LS-OPT lists all the entities defined in the file. Select the entity (part_2) to defined it as an LS-OPT response with *d3hsp* being the input data file, as shown in figure 5. Repeat this process to define LS-OPT responses for all parts.

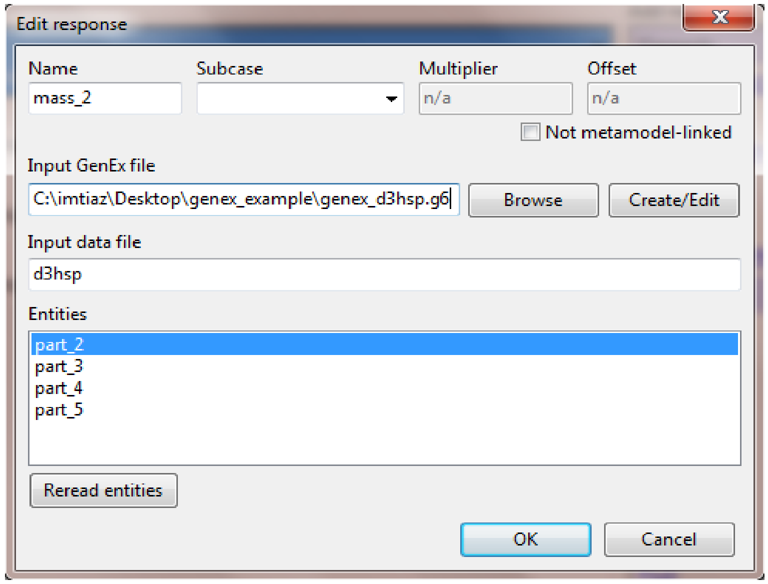

Figure 5: Defining GenEx response in LS-OPT

13. To create GenEx responses for extracting nodal displacements, similar steps can be followed with *nodout* being the input data file. The sample *nodout* file (sample_nodout) provided with the example can be used to create the required genex input file. An anchor can be created to search for text 'x-disp'. By default, this anchor is created under *Start of file* anchor with *forward* search direction and hence the search results in locating first occurrence of 'x-disp' within *nodout* data file. Since last reported displacement values are required, the *anchor origin* can be changed to '*End of file*' with *backward* search direction as shown in figure 6. Entities for x-displacement of both nodes (432 and 167) can be defined under this anchor.

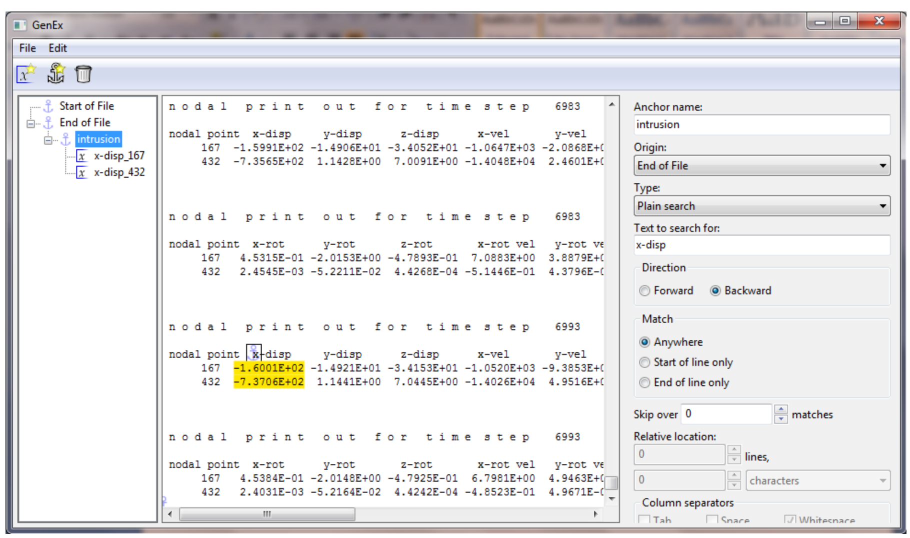

Figure 6: Changing anchor origin and search direction for backward search in GenEx

14. Once all the required entities are defined, the process is saved as *genex_nodout.g6* and *Step 12* can be repeated to define LS-OPT responses using this genex file with *nodout* being the input data file.
15. These GenEx responses as any other LS-OPT responses can be assigned as optimization objectives/constraints.

Defining Histories in GenEx:

1. Even though histories are not utilized in this example problem, internal energy, nodal acceleration and rigid wall force histories have been defined to demonstrate the use of GenEx for extracting histories from an input data file.
2. Similar to responses, GenEx histories require an input data file and its corresponding .g6 genex file, as shown in figure 7.

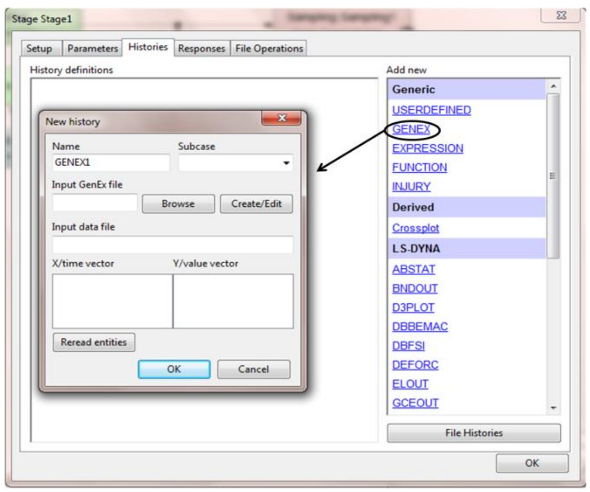

Figure 7: GenEx history dialog box

3. To create internal energy history, click on GENEX and assign a name to the history. LS-DYNA ASCII file *glstat* is used as input data file, i.e. internal energy history is extracted from *glstat*. To create .g6 file (genex input file), click on *Create/Edit* to open GenEx window and select *sample_glstat* as input file from the GenEx window (File → Select input file).
4. Now Anchors and Entities should be defined to locate internal energy values at each time interval.
5. To define an anchor, click on *New Anchor*, assign a name (e.g. cycle) and enter “dt of cycle” in ‘*Text to search for*’ field and hit enter. This creates an anchor at start of first occurrence of text “dt of cycle”.
6. Now create entities for time (x vector) and internal energy values (y vector) using this anchor. Click on *‘New Entry’* and find the relative location of internal energy values with the defined anchor. The relative location can be determined using *lines*, *characters* and *columns* options. In this example, the entity *IE_value* is located at 5th line 2nd column relative to the anchor “cycle” and the entity *time* are located at 2nd line 1st column (with whitespace as column separator).

7. Since this is a history, the entities *time* and *IE_value* at each cycle should be extracted. This can be done by selecting *Repeated Anchor Vector* as entity type. Selecting *Repeated Anchor Vector* as anchor type highlights all the fields with locations relative to text "dt of cycle" throughout the data file *sample_glstat*, as shown in figure 8. Once all the anchors and entities are defined, save the GenEx file and close the GenEx window.

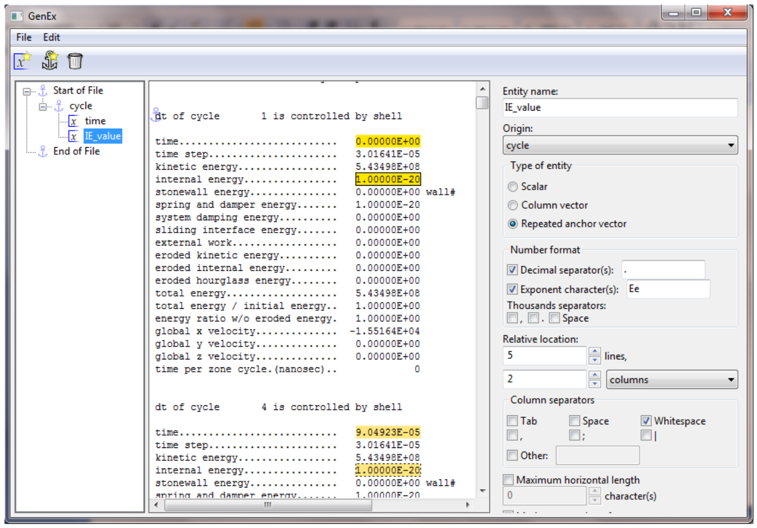

Figure 8 History definition using Repeated Anchor Vector

8. Now select the GenEx file created in previous steps as 'input GenEx file' of history and *sample_glstat* as 'input data file'. Once the GenEx file is selected, the entities defined are listed under X/time vector and Y/value vectors. Select *time* entity as X vector and *IE_value* as Y vector and click *Ok*, figure 9. Internal energy history using GenEx has been defined. When LS-OPT is executed, the defined entity fields are extracted as histories from *glstat* ASCII files generated as a result of LS-DYNA analysis in each run directory.

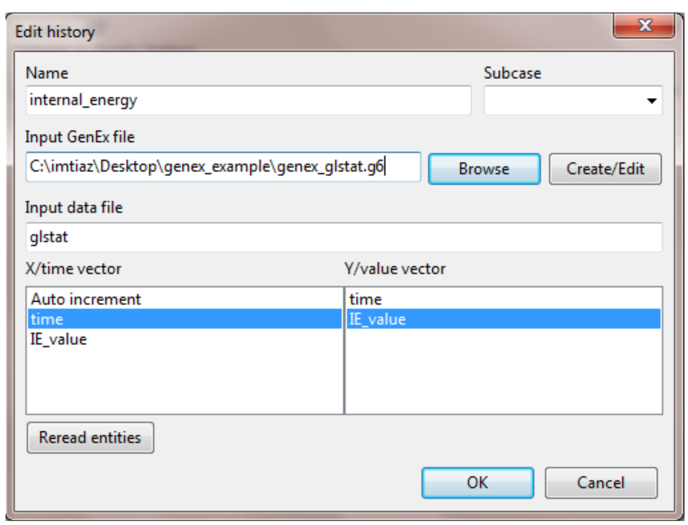

Figure 9: Defining GenEx history in LS-OPT

9. Similarly nodal acceleration history can be formulated using *Repeated Anchor Vector* for *nodout* input data file and the input genex file (*genex_nodout*) used for nodal displacement responses can be modified to include history entities.
10. The rigid wall force history can be extracted from *rwforc* data file. In this example since only one rigid wall has been defined, the *rwforce* history (*time* vs. *force*) values are printed as a list. Therefore, after defining the anchor, the *type of entity* can be selected as *Column Vector* instead of using *Repeated Anchor Vector*. When *Column Vector* is selected all the components below the selected entity are highlighted till the end of file, as shown in figure 10.

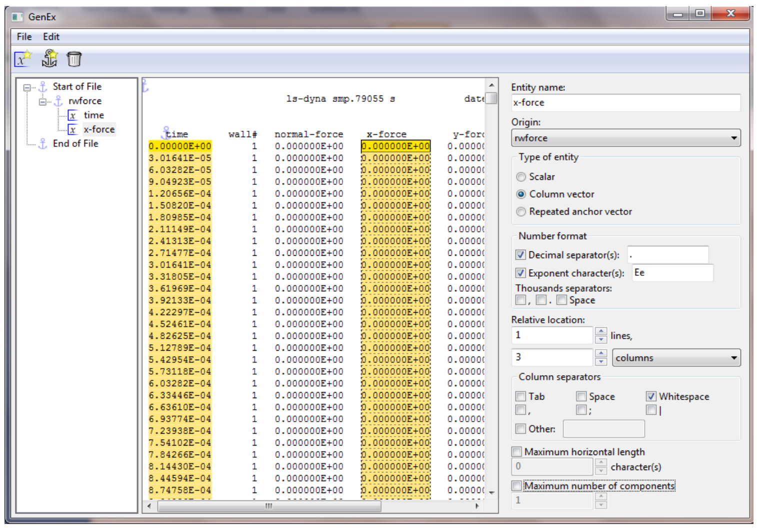

Figure 8 History definition using Column Vector as entity type

11. If a user wants only few components of the column, *Maximum Horizontal Components* check box can be used to define the required number of components.
12. Once the genex file is created, LS-OPT histories can be defined using this file as explained in *Step 8*.

Optimization Results:

- The optimization problem was solved using metamodel-based sequential optimization with domain reduction technique.
- The process took seven iterations (with five design points in each iterations) to converge.
- At the optimum design, the total mass of selected parts is 0.465Kg and the computed intrusion distance is 549.29mm vs. 550mm predicted by the metamodel.