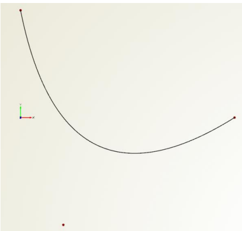
Connecting External Software

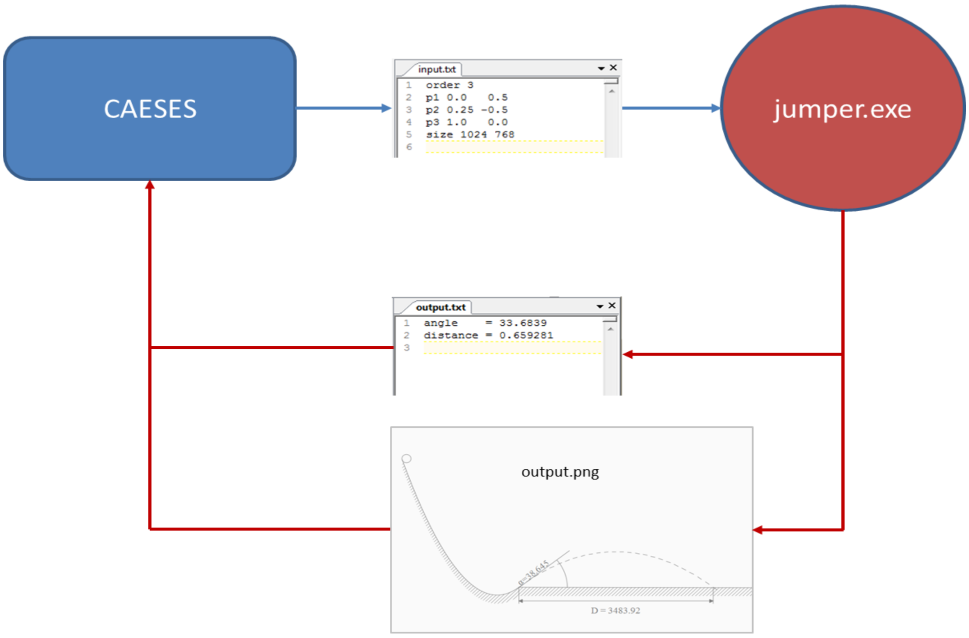
External software can be coupled to CAESES in order to analyze and optimize geometry designs. In particular, CFD simulations are addressed, which can be conveniently involved in the design process. This tutorial introduces the basic principles of the coupling mechanisms by means of an arbitrary external tool. CFD-focused examples can be found in following tutorials (*Getting Started > External Software*).

External Tool: jumper.exe

In order to keep the procedure easy, a very simple tool called "jumper.exe" is integrated. It calculates the flying distance "D" of a ball after it is accelerated over a curved ramp.



The curved ramp is modelled in CAESES as bspline curve. The points of this curve are written into an input file for the jumper.exe. Then, the jumper tool calculates the distance "D" and writes it into an output file, and it additionally exports a png-file that gives an impression of the situation:



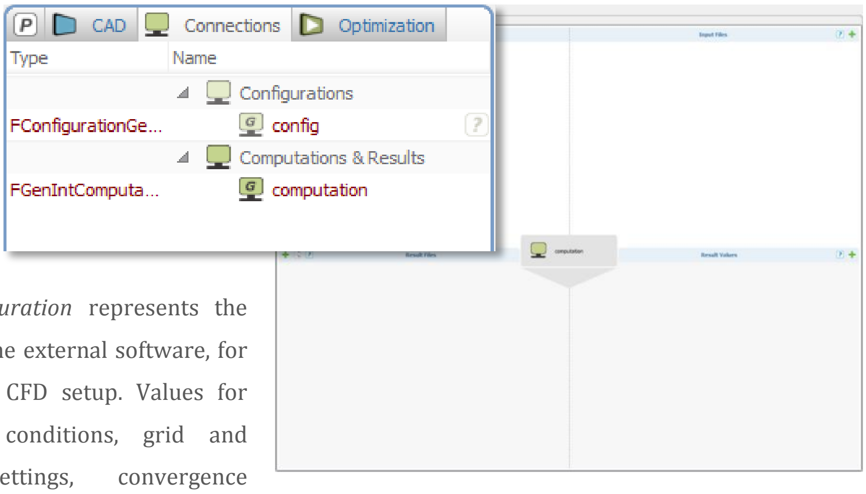
Objective: Find the maximum distance

The goal is to find the optimal accelerating curve, which yields the maximal distance "D".

Software Connector

The *software connector* is the administration object that configures the data exchange between CAESES and the external software.

▶ From the menu, select *connections > new software connector*. This creates a new configuration and a new computation object (see the connections tab).



The *configuration* represents the setup for the external software, for instance a CFD setup. Values for boundary conditions, grid and solver settings, convergence criteria etc. can be set in the configuration. In addition, any information about input and output files will be stored in the configuration (this is automatically done via the *software connector*).

✓ The explanation of how to add entries to a configuration is given in step 3 of this tutorial.

The *computation* will contain information about the external application (e.g. executable path, batch mode arguments, constraints, SSH settings for distributed computing etc., see step 7).

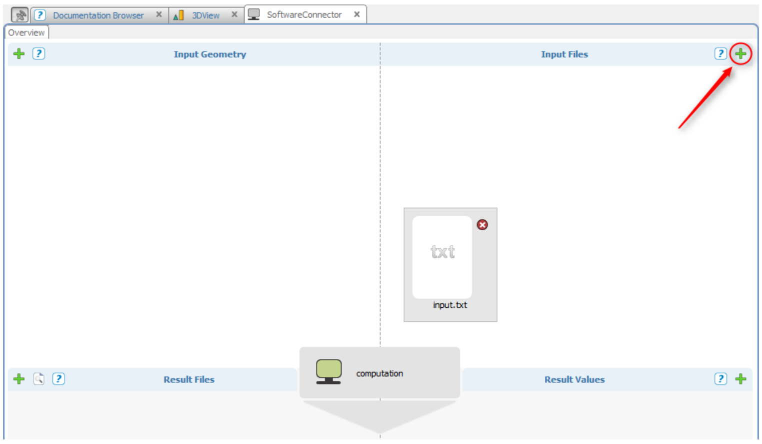
2 External Tool Input File

The input for the external tool consists of an ASCII file, which supplies the coordinates for the three control points that define the shape of a cubic B-spline curve. This curve represents the ramp that accelerates the ball.

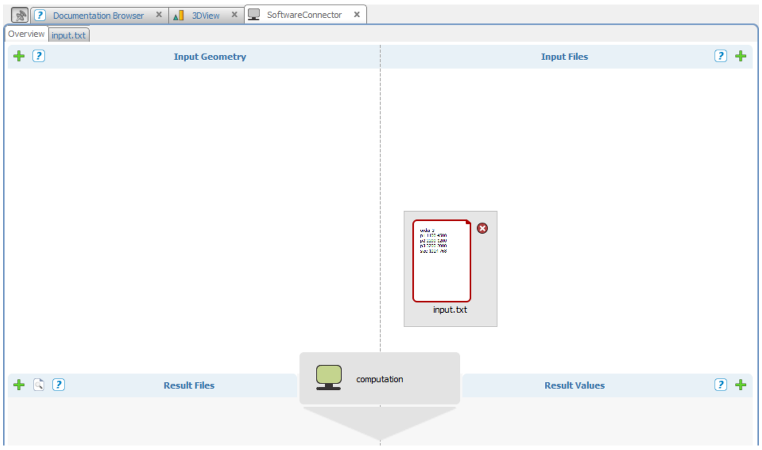
We will start by loading an existing input file into the software connector:

- Add an input file to the software connector via the "+" icon in the top right corner of the second quadrant. The "input.txt" file can be found in the directory CAESES *installation directory > samples > integration > jumper*.
- The file will appear as an icon in the input file quadrant.

Since we want to modify this input file before the computation is started (replace fixed values with variable ones), we will convert it into a template:



- Double click on the "input .txt" file icon. This will slightly transform the icon and open the template editor.

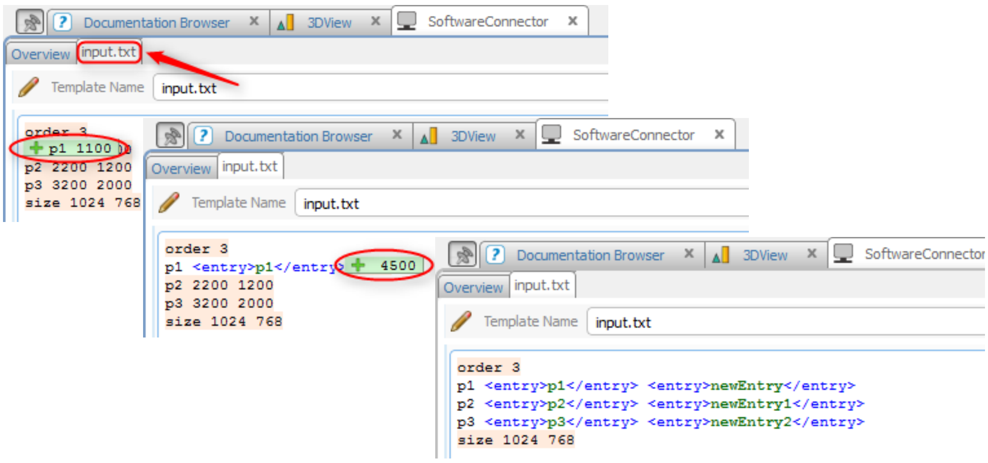


3 Modifying the Input File Template

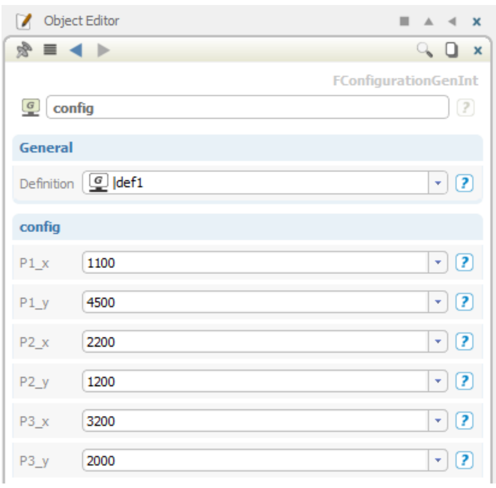
Now we want to replace the fixed values for the point coordinates in the input file with variables that should in the end be supplied by our geometry model.

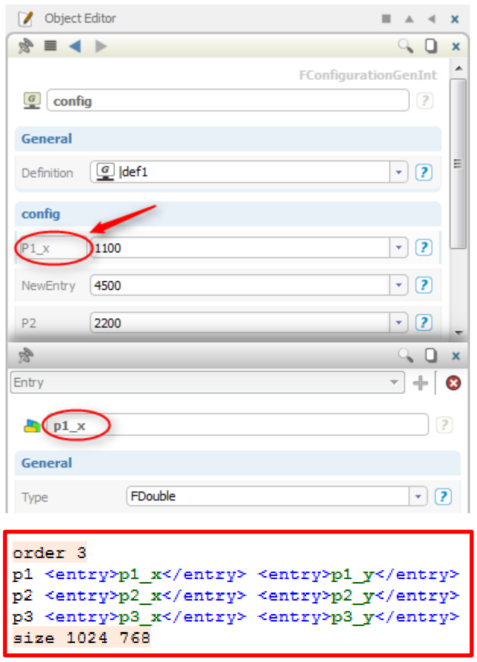
The template editor has an automatic number detection that highlights available numbers in the template file.

- In the template editor click on the first green-colored number detection field (x-coordinate of first point). This will replace the number by a tag and create a linked entry in the configuration.
- Repeat this for the y-coordinate, as well as for all subsequent point coordinates.



- Now rename the configuration entries by clicking on the label in front of the corresponding editor field.





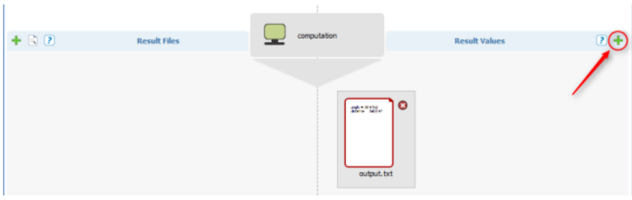
4

Parsing ASCII Output File

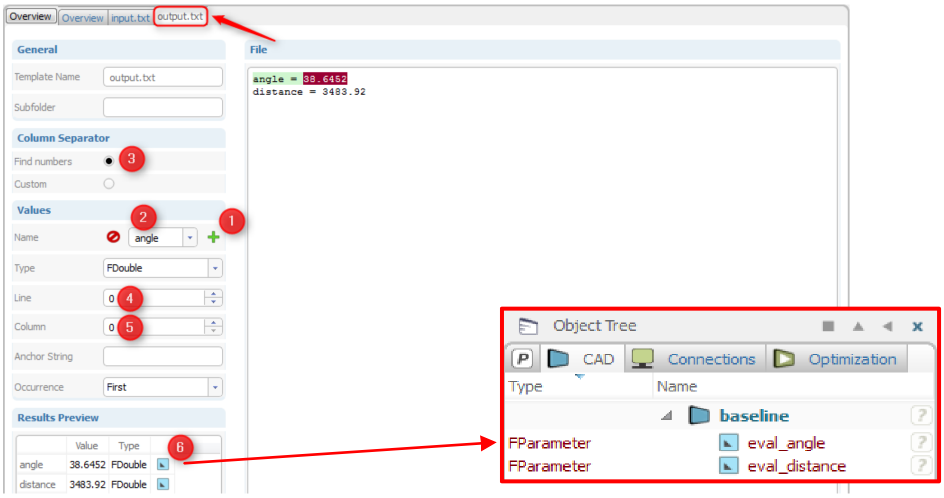
The result values that are computed by the external tool are supplied in another ASCII file. These values should be made available as result *parameters* in CAESES.

We will load an existing output file into the result value parser of the *software connector*:

- Import the template result file by clicking on the “+” button of the quadrant “result values”. The “output.txt” file can be found in same directory as the input file.
- Click on the corresponding tab (or double-click on the file icon of your imported result file) in the software connector.



- In the category *values*, add a new item by clicking on the “+” icon and set a name i.e. identifier, such as “angle”.
- Use the *line* and *column* editors in order to detect the value of interest. There is a window “results preview” with a table showing the detected values.
- Repeat the process for the second value and call it “distance”.



The values will be provided in a table after the computation run has finished.

- Create parameters for these values by clicking on the blue parameter icons next to the table values (point “6” in the picture). The parameters are created in the *CAD object tree* and are connected to these result values (i.e. dependent on the *computation*, see step 7).

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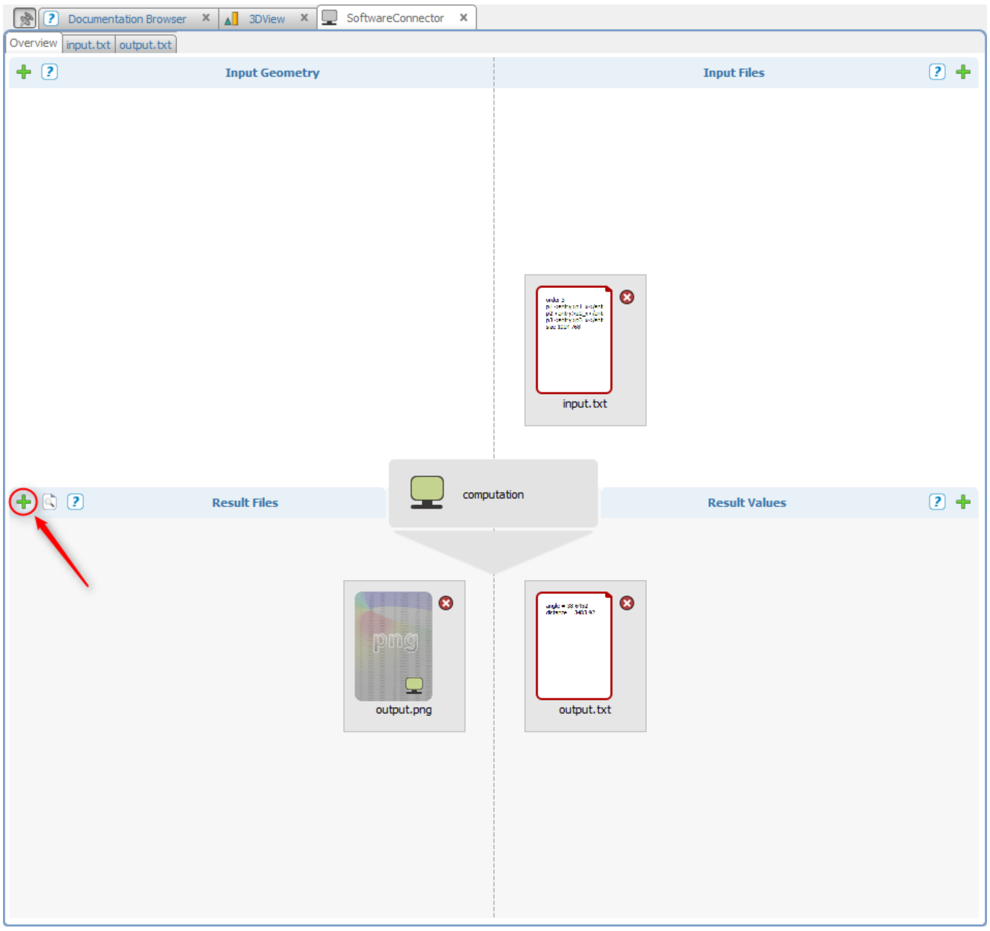
PNG Result File

A further output of the external tool is a PNG picture with a visualization of the result. This should also be imported.

- ▶ Add the PNG file to the list of loaded result files by clicking on the “+” button of the “result files” quadrant. The “output.png” file can be found in same directory as the input and output files.

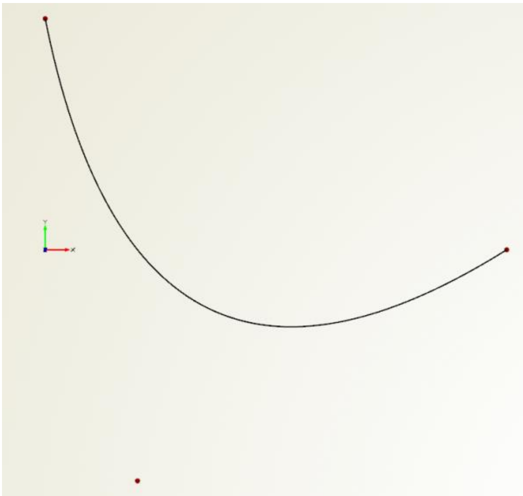


6 Geometry Modelling

The B-spline curve that is used by the external tool will be generated in CAESES. The geometry model should then be connected to the configuration of the external tool.

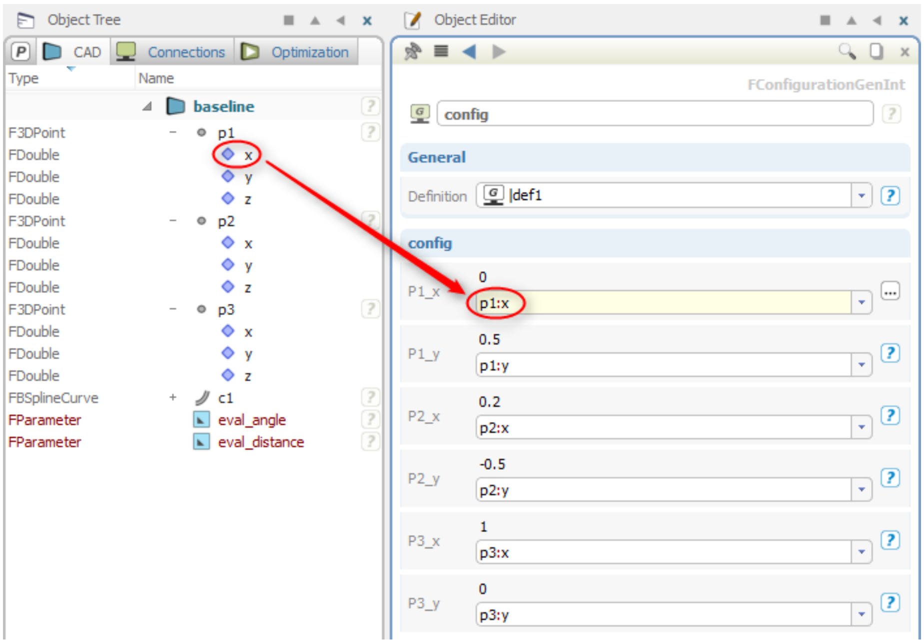
- Create a B-spline curve with three *points*, e.g. via *CAD > curves > B-spline curve*.
- The coordinates shall be initially set with the following coordinates:

```
p1 = [0,0.5,0]

p2 = [0.2,-0.5,0]

p3 = [1,0,0]
```



- Connect the coordinates of the three *points* with the corresponding entries in the configuration, e.g. by dragging and dropping them into the editor fields.

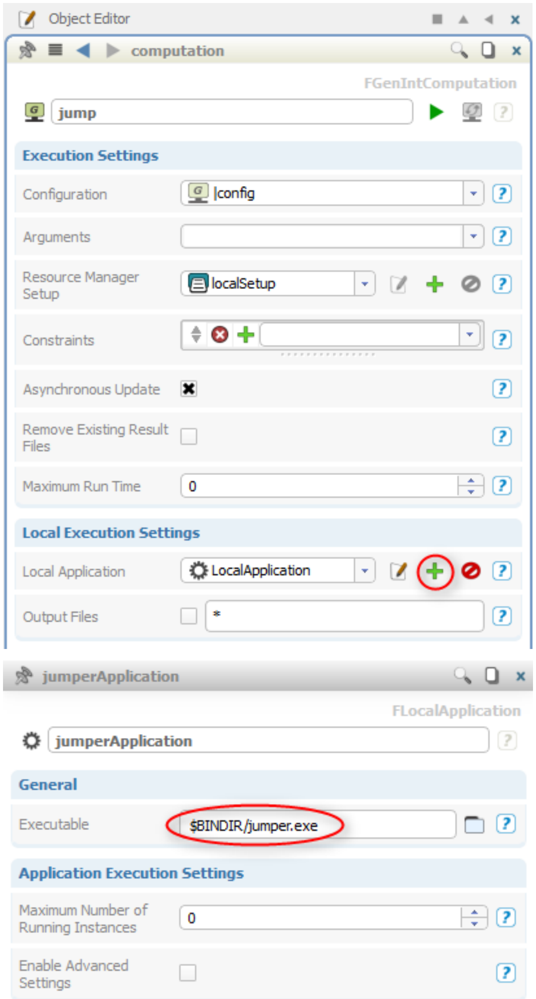
When a computation is started, the configuration is evaluated and the input file for the external tool is generated according to the template. At that time the current coordinate values of the points are inserted into the input file at the positions of the tags that were added in step 3.

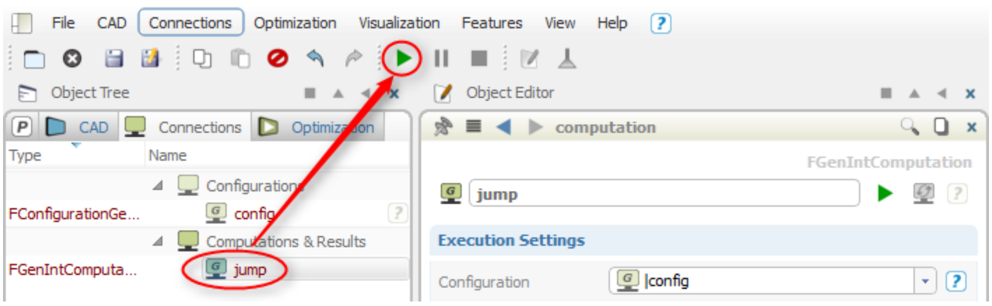


7 Computation Setup and Run

Now everything is prepared so that the first computation can be started. But first we have to tell CAESES where to find the executable of the external software.

- Select the computation in the center of the software connector or in the object tree under *connections*.
- Change the name to “jump”.
- Create a new local application by clicking on the “+” button under “local execution settings”.
- Set the name for the application and the path to the external executable. The executable “jumper.exe” is located in the directory CAESES *installation directory > bin > win64/win32* (can be simply specified as $BINDIR).
- Start the computation, e.g. by selecting it in the object tree and clicking on the run button (▶) in the top toolbar.

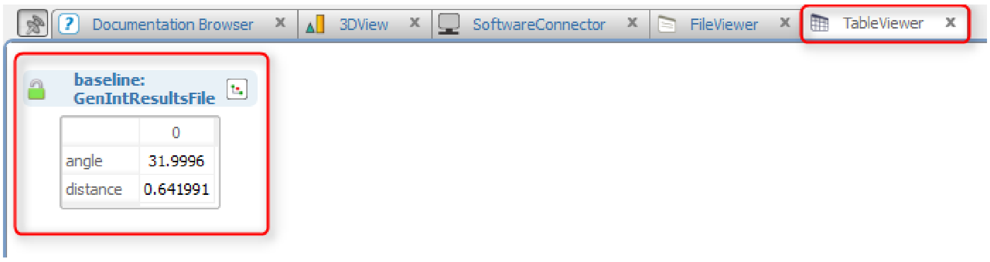




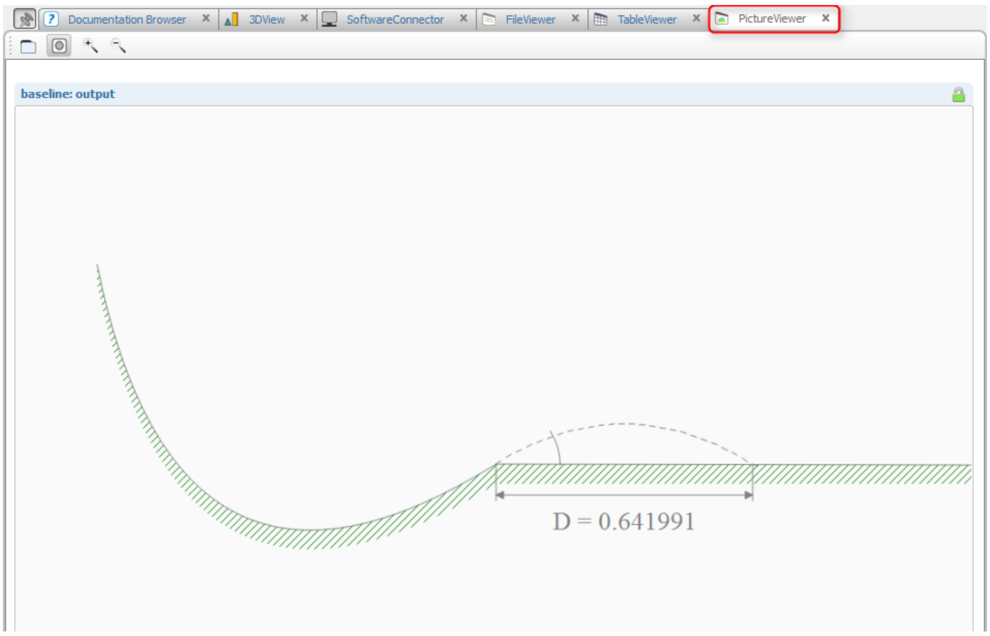
8 Results

When the external tool has finished running (it will take less than a second), we can take a look at the results that were generated and imported into CAESES.

- Open the table viewer and take a look at the result table with the two extracted values.



- Open the picture viewer and take a look at the imported picture.



If the viewers are not visible, you might have to turn them on via *menu > view > windows*.

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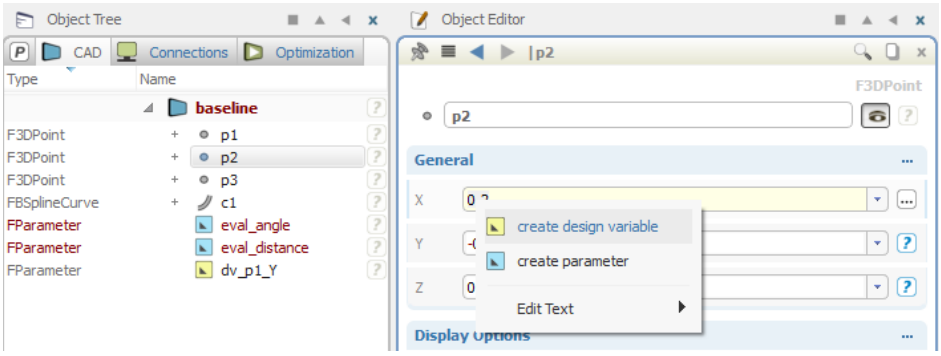
Optimization Setup

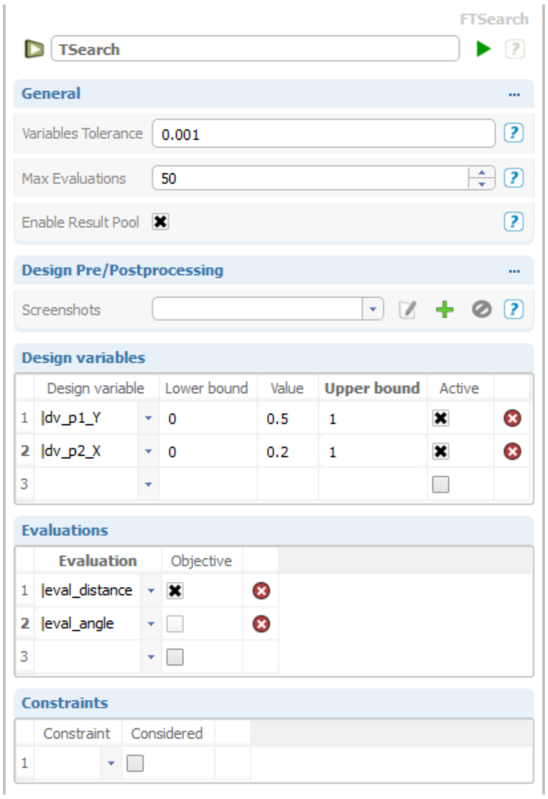
After confirming that the computation run was successful, we want to run a small optimization to see if we can improve the throwing distance of the ball by modifying the ramp geometry.

First of all we need to define the degrees of freedom of our geometry by introducing design variables:

- Select the first point (“p1”) and introduce a design variable for the y-coordinate.
- Add a further design variable for the x-coordinate of the second point (“p2”).



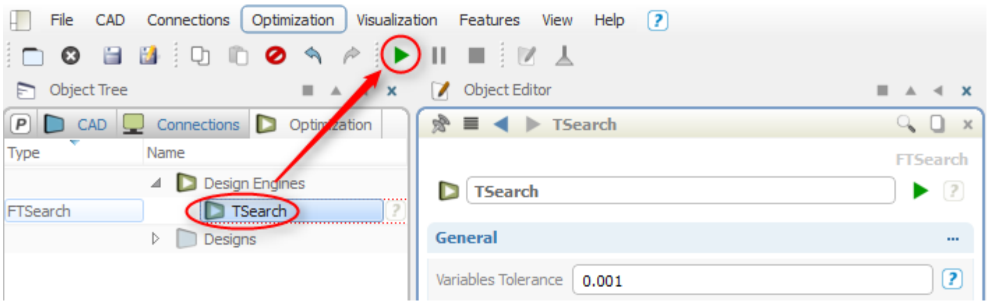
- Create a *TSearch design engine* (*menu > optimization > TSearch*). Add the two design variables and set bounds of [0,1] for both.
- Add the two evaluation parameters as well and select only “eval_distance” as objective
- Since by default all design engines are set to minimize the objectives, modify the distance parameter by multiplying the value with “-1” (select the parameter “eval_distance” in the CAD tree and edit the expression).



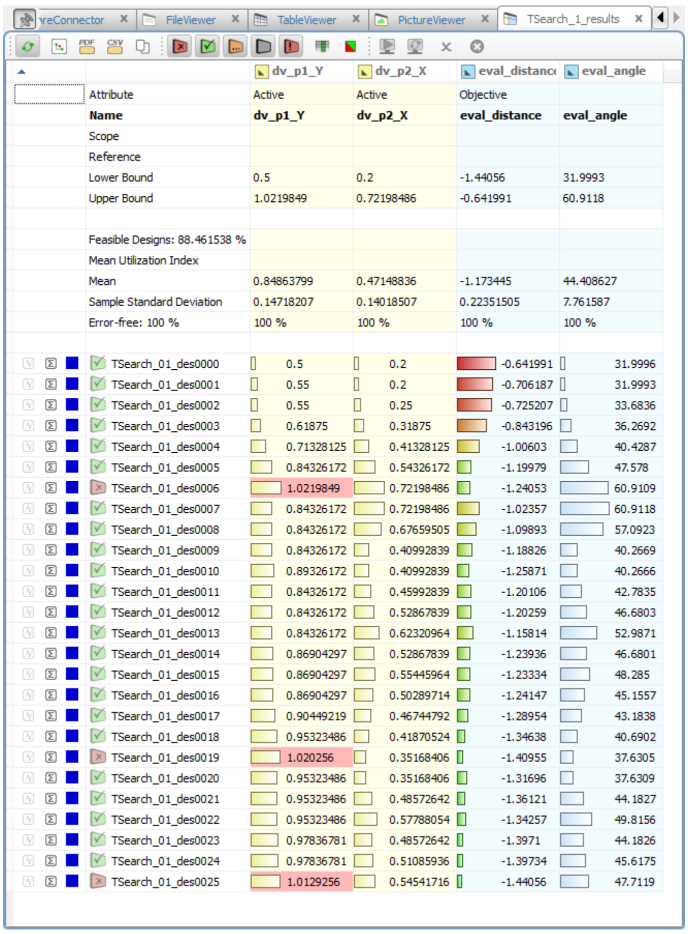
10 Optimization Run

Now finally, we run the optimization and analyze the results.

- Start the design engine, e.g. by selecting it in the object tree and clicking on the run button (▶) in the top toolbar.



- Take a look at the generated result table and browse through the variants in the object tree (node *designs* in the tab *optimization*) in order to display the corresponding pictures of each variant in the picture viewer.



	dv_p1_Y	dv_p2_X	eval_distance	eval_angle
Attribute	Active	Active	Objective	
Name	**dv_p1_Y**	**dv_p2_X**	**eval_distance**	**eval_angle**
Scope				
Reference				
Lower Bound	0.5	0.2	-1.44056	31.9993
Upper Bound	1.0219849	0.72198486	-0.641991	60.9118
Feasible Designs: 88.461538 %				
Mean Utilization Index				
Mean	0.84863799	0.47148836	-1.173445	44.408627
Sample Standard Deviation	0.14718207	0.14018507	0.22351505	7.761587
Error-free: 100 %	100 %	100 %	100 %	100 %
TSearch_01_des0000	0.5	0.2	-0.641991	31.9996
TSearch_01_des0001	0.55	0.2	-0.706187	31.9993
TSearch_01_des0002	0.55	0.25	-0.725207	33.6836
TSearch_01_des0003	0.61875	0.31875	-0.843196	36.2692
TSearch_01_des0004	0.71328125	0.41328125	-1.00603	40.4287
TSearch_01_des0005	0.84326172	0.54326172	-1.19979	47.578
TSearch_01_des0006	1.0219849	0.72198486	-1.24053	60.9109
TSearch_01_des0007	0.84326172	0.72198486	-1.02357	60.9118
TSearch_01_des0008	0.84326172	0.67659505	-1.09893	57.0923
TSearch_01_des0009	0.84326172	0.40992839	-1.18826	40.2669
TSearch_01_des0010	0.89326172	0.40992839	-1.25871	40.2666
TSearch_01_des0011	0.84326172	0.45992839	-1.20106	42.7835
TSearch_01_des0012	0.84326172	0.52867839	-1.20259	46.6803
TSearch_01_des0013	0.84326172	0.62320964	-1.15814	52.9871
TSearch_01_des0014	0.86904297	0.52867839	-1.23936	46.6801
TSearch_01_des0015	0.86904297	0.55445964	-1.23334	48.285
TSearch_01_des0016	0.86904297	0.50289714	-1.24147	45.1557
TSearch_01_des0017	0.90449219	0.46744792	-1.28954	43.1838
TSearch_01_des0018	0.95323486	0.41870524	-1.34638	40.6902
TSearch_01_des0019	1.020256	0.35168406	-1.40955	37.6305
TSearch_01_des0020	0.95323486	0.35168406	-1.31696	37.6309
TSearch_01_des0021	0.95323486	0.48572642	-1.36121	44.1827
TSearch_01_des0022	0.95323486	0.57788054	-1.34257	49.8156
TSearch_01_des0023	0.97836781	0.48572642	-1.3971	44.1826
TSearch_01_des0024	0.97836781	0.51085936	-1.39734	45.6175
TSearch_01_des0025	1.0129256	0.54541716	-1.44056	47.7119