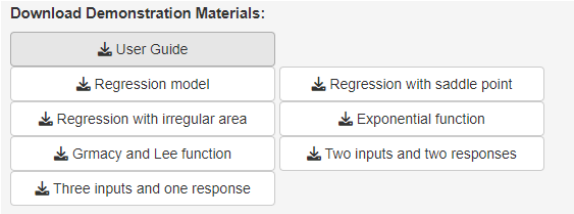
# Fast Input-Response Space Filling (FIRSF) Designs Application User Guide

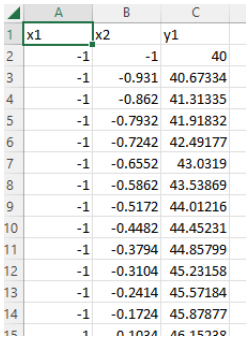
## Section 1: Data Preparation

### Section 1.1: Prepare Data

#### Section 1.1.1: Download Reference Materials

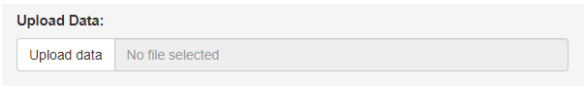



- You may download a sample data set by clicking buttons below the "***User Guide***" button such as "***Regression model***" button. The example data set consists of two groups of candidate data. Attached below is an image of the first few rows of the example data set. You may also download this guide by clicking the "***User Guide***" button

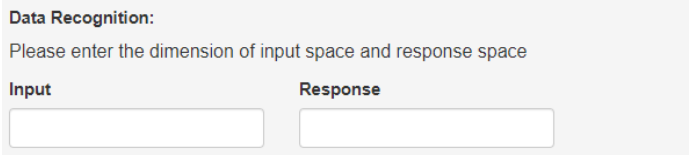


| | A | B | C |
|---|---|---|---|
| 1 | x1 | x2 | y1 |
| 2 | -1 | -1 | 40 |
| 3 | -1 | -0.931 | 40.67334 |
| 4 | -1 | -0.862 | 41.31335 |
| 5 | -1 | -0.7932 | 41.91832 |
| 6 | -1 | -0.7242 | 42.49177 |
| 7 | -1 | -0.6552 | 43.0319 |
| 8 | -1 | -0.5862 | 43.53869 |
| 9 | -1 | -0.5172 | 44.01216 |
| 10 | -1 | -0.4482 | 44.45231 |
| 11 | -1 | -0.3794 | 44.85799 |
| 12 | -1 | -0.3104 | 45.23158 |
| 13 | -1 | -0.2414 | 45.57184 |
| 14 | -1 | -0.1724 | 45.87877 |

#### Section 1.1.2: Upload Data




- In ***Upload Data*** part, please click the ***Upload File*** button to upload a .csv file with your data. Please check that the data has the same format as the example data given above. The data set should contain two parts. The first part contains the $n$-dimensional input candidate set as $n$ columns in the tables, and the second part contains the $m$-dimensional response candidate set as $m$ columns in the tables. The order should be {***input set***, ***response set***}.

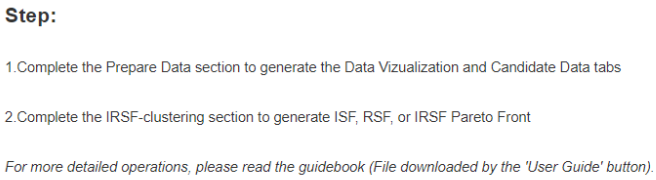



- After the data set is uploaded, please use the textboxes in ***Data Recognition*** section to enter the dimension of input space (***Input*** textbox) and response space (***Response*** textbox) to let this

application recognize input part and response part of candidate set. Then the application automatically populates the ***Data Visualization*** tab.

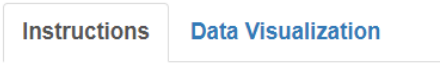
## Section 1.2: Validate Data

### Section 1.2.1: Instruction

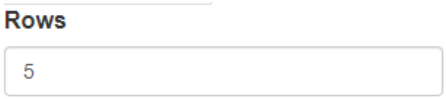



- In the ***Instructions*** tab, the page show the procedure of this application. For more information, please read this guidebook.

### Section 1.2.2: Data Visualization

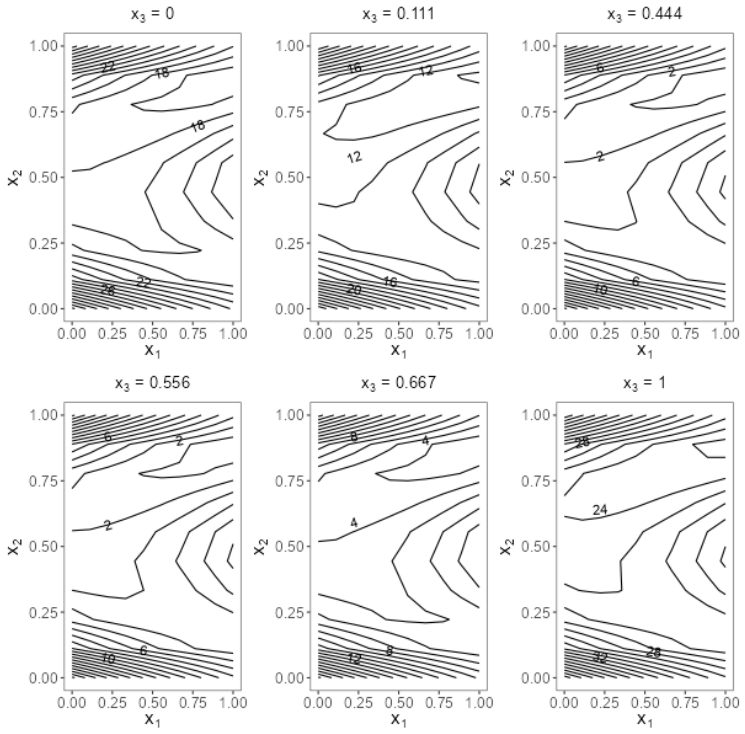



- After inputting the dimensions of input space and response space, you can click the ***Data Visualization*** tab to view the data structure. The plots are available for lower dimensional cases (1d input and 1d response; 2d input and 1d response; 3d input and 1d response; 2d input and 2d response).

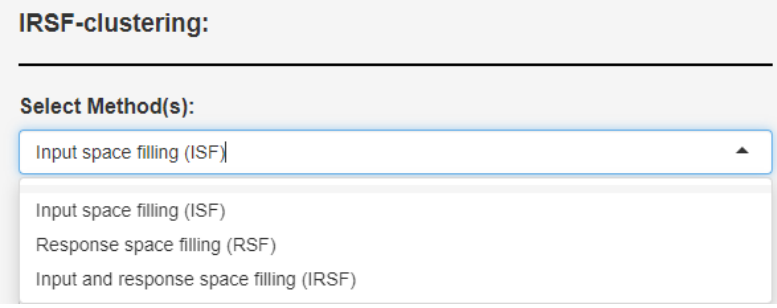



- Please enter the number of rows of candidate set in ***Rows*** textbox. The default number is "**5**". After the number of "***Rows***" be entered, the table sample and plots (for special dimensional cases) would be shown in the page as below. Here the 3 dimensional input space and 1 dimensional response space would be utilized as an example.

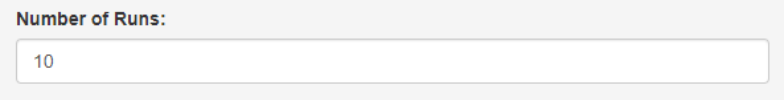
| x1 | x2 | x3 | y1 |
|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 35.00 |
| 0.11 | 0.00 | 0.00 | 33.27 |
| 0.22 | 0.00 | 0.00 | 31.64 |
| 0.33 | 0.00 | 0.00 | 30.11 |
| 0.44 | 0.00 | 0.00 | 28.68 |


x3 = 0
x3 = 0.111
x3 = 0.444
x3 = 0.556
x3 = 0.667
x3 = 1
x1
x2
0.00
0.25
0.50
0.75
1.00

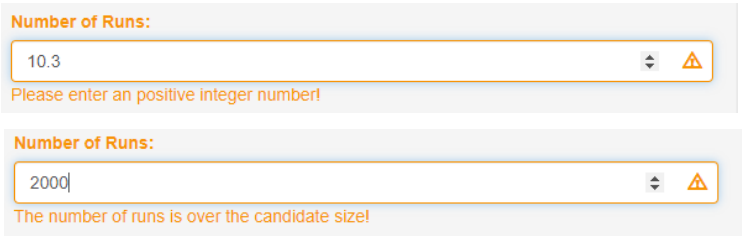
## Section 2: FIRSF Designs



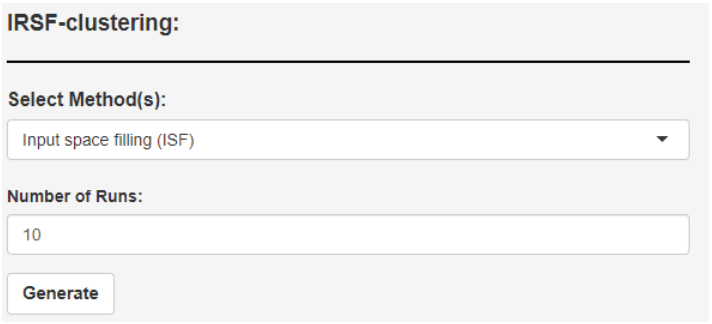

- After the candidate set is uploaded and the dimensions of input space and response space are entered, the method of space-filling designs needs to be selected with the ***Select Method(s)*** menu. There are three choices including input space-filling (ISF) designs, response space-filling (RSF) designs, and input-response space-filling (IRSF) designs.




- Please use the ***Number of Runs*** textbox to enter the number of runs in a design. The default number is "**10**". The number requires that it is a positive integer number, and it cannot be over the candidate set size. If a number is not a positive integer number or over the candidate set size, a warning message would be given as below.




## Section 2.1: ISF




- If you select ***Input space filling (ISF)*** from the ***Select Method(s)*** menu and enter a number in the ***Number of Runs*** textbox, click the ***Generate*** button to process input space-filling (ISF) design.

Instructions | Data Visualization | ISF

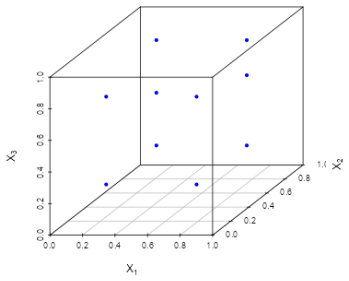
**ISF Design Table**

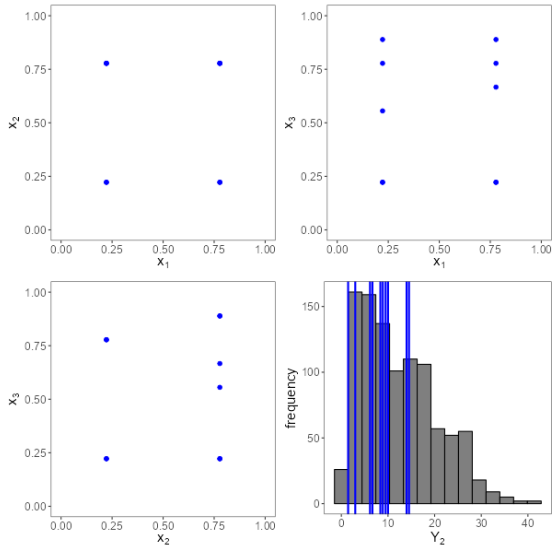
| x1 | x2 | x3 | y1 |
|---|---|---|---|
| 0.22 | 0.22 | 0.22 | 8.89 |
| 0.78 | 0.22 | 0.22 | 8.37 |
| 0.22 | 0.78 | 0.22 | 6.67 |
| 0.78 | 0.78 | 0.22 | 6.14 |
| 0.22 | 0.22 | 0.78 | 10.01 |
| 0.78 | 0.22 | 0.78 | 9.49 |
| 0.22 | 0.78 | 0.56 | 1.45 |
| 0.78 | 0.78 | 0.67 | 2.98 |
| 0.22 | 0.78 | 0.89 | 14.51 |
| 0.78 | 0.78 | 0.89 | 13.99 |

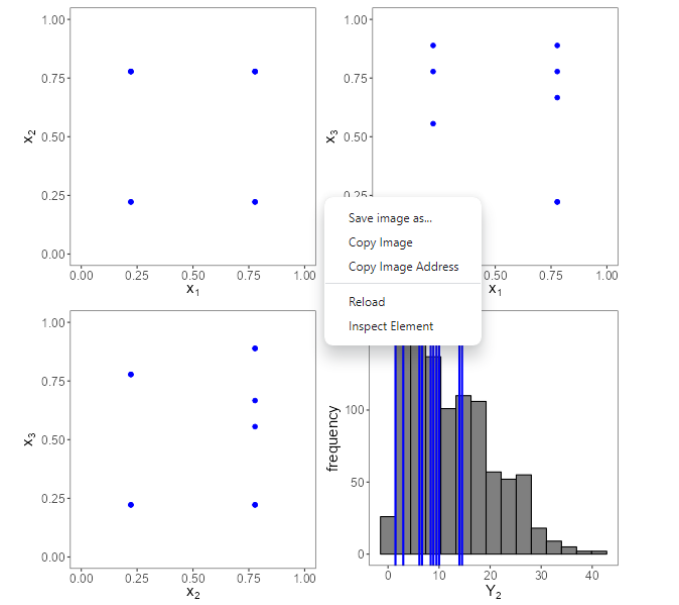
- After you click the ***Generate*** button, please click ***ISF*** tab to check the result. In ***ISF*** tab page, there is a ***ISF Design Table*** given here. If your data satisfy the plot condition (1d input and 1d response; 2d input and 1d response; 3d input and 1d response; 2d input and 2d response), you will also get the related design plot. The following figure shows a result for a 3-dimensional input space and 1-dimensional response space case. You can also right-click the plot to save or copy the image.

**ISF Design Table**

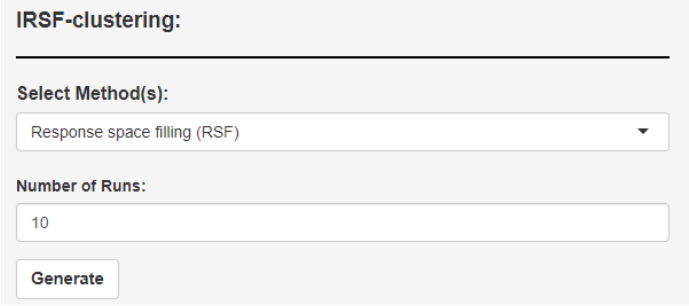
| x1 | x2 | x3 | y1 |
|---|---|---|---|
| 0.22 | 0.22 | 0.22 | 8.89 |
| 0.78 | 0.22 | 0.22 | 8.37 |
| 0.22 | 0.78 | 0.22 | 6.67 |
| 0.78 | 0.78 | 0.22 | 6.14 |
| 0.22 | 0.22 | 0.78 | 10.01 |
| 0.78 | 0.22 | 0.78 | 9.49 |
| 0.22 | 0.78 | 0.56 | 1.45 |
| 0.78 | 0.78 | 0.67 | 2.98 |
| 0.22 | 0.78 | 0.89 | 14.51 |
| 0.78 | 0.78 | 0.89 | 13.99 |



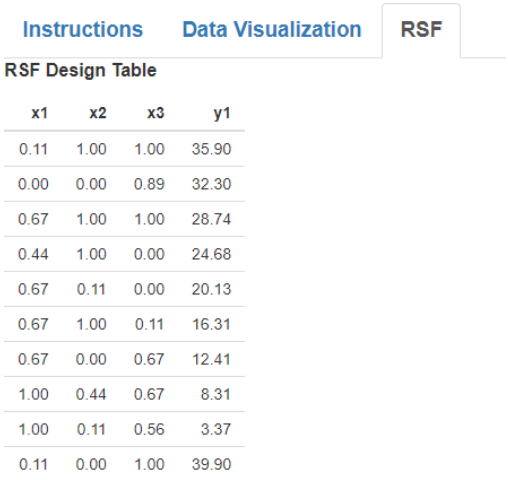






## Section 2.2: RSF




- If you select ***Response space filling (ISF)*** from the ***Select Method(s)*** menu and enter a number in the ***Number of Runs*** textbox, click the ***Generate*** button to process input space-filling (ISF) design.

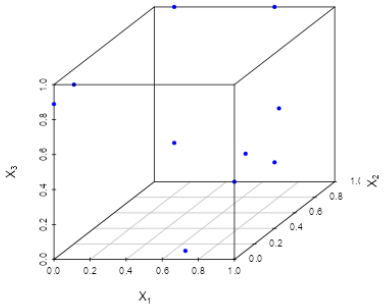


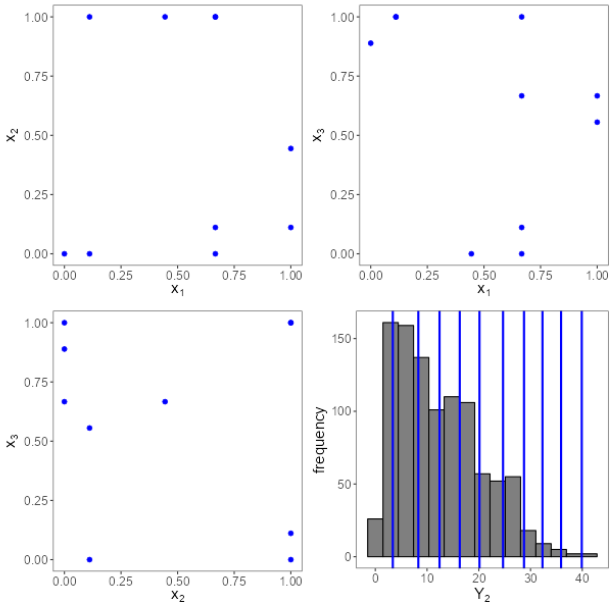

| x1 | x2 | x3 | y1 |
|---|---|---|---|
| 0.11 | 1.00 | 1.00 | 35.90 |
| 0.00 | 0.00 | 0.89 | 32.30 |
| 0.67 | 1.00 | 1.00 | 28.74 |
| 0.44 | 1.00 | 0.00 | 24.68 |
| 0.67 | 0.11 | 0.00 | 20.13 |
| 0.67 | 1.00 | 0.11 | 16.31 |
| 0.67 | 0.00 | 0.67 | 12.41 |
| 1.00 | 0.44 | 0.67 | 8.31 |
| 1.00 | 0.11 | 0.56 | 3.37 |
| 0.11 | 0.00 | 1.00 | 39.90 |

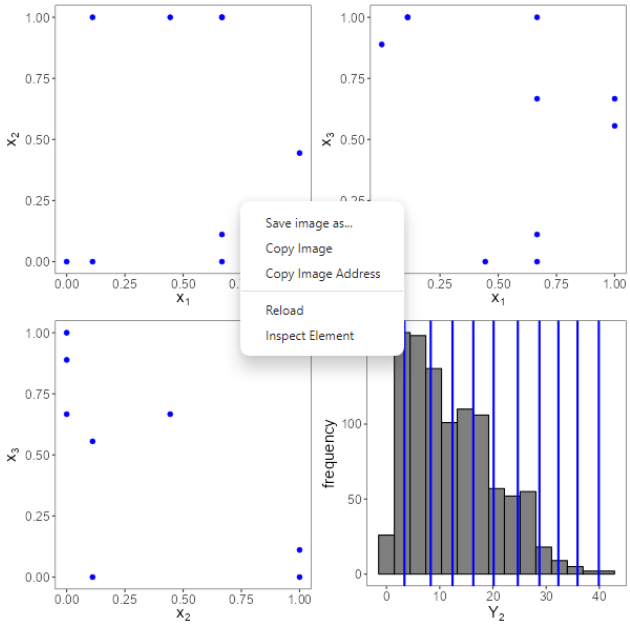
- After you click the ***Generate*** button, please click ***RSF*** tab to check the result. In ***RSF*** tab page, there is a ***RSF Design Table*** given here. If your data satisfy the plot condition (1d input and 1d response; 2d input and 1d response; 3d input and 1d response; 2d input and 2d response), you will also get the related design plot. The following figure shows a result for a 3-dimensional input space and 1-dimensional response space case. You can also right-click the plot to save or copy the image.

**RSF Design Table**

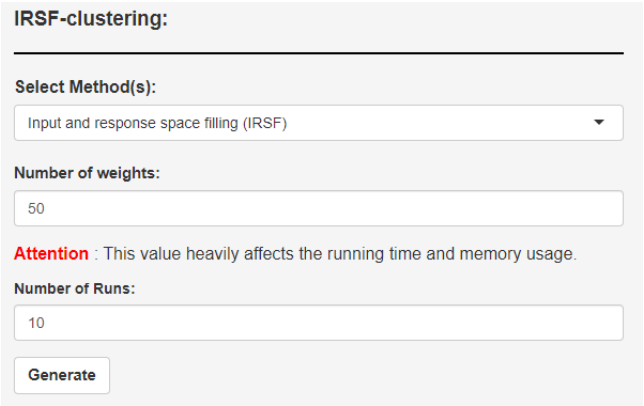
| x1 | x2 | x3 | y1 |
|---|---|---|---|
| 0.11 | 1.00 | 1.00 | 35.90 |
| 0.00 | 0.00 | 0.89 | 32.30 |
| 0.67 | 1.00 | 1.00 | 28.74 |
| 0.44 | 1.00 | 0.00 | 24.68 |
| 0.67 | 0.11 | 0.00 | 20.13 |
| 0.67 | 1.00 | 0.11 | 16.31 |
| 0.67 | 0.00 | 0.67 | 12.41 |
| 1.00 | 0.44 | 0.67 | 8.31 |
| 1.00 | 0.11 | 0.56 | 3.37 |
| 0.11 | 0.00 | 1.00 | 39.90 |



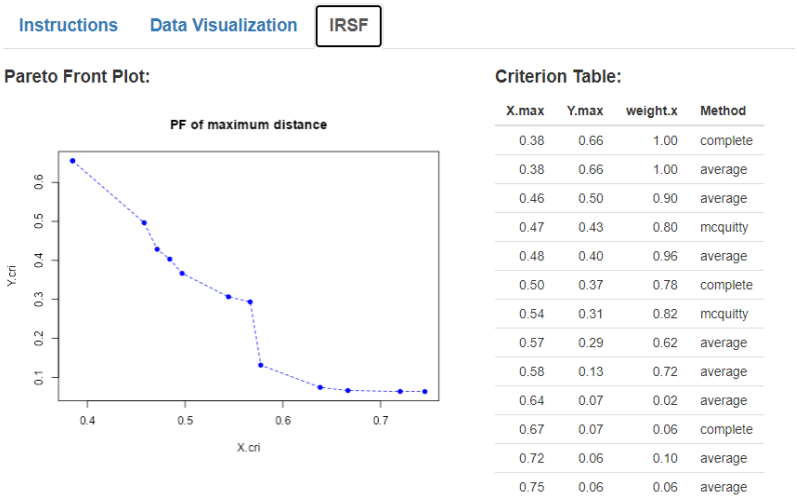






**Section 2.3: IRSF**




- If you select ***Input and Response space filling (IRSF)*** from the ***Select Method(s)*** menu, there is a new textbox shown in ***IRSF-clustering*** section, named ***Number of weights***. The value in the ***Number of weights*** textbox decides how many weights systematically chosen from 0 to 1 are selected to run the FIRSF function. The default value is "50". Please be careful to enter the number of weights since "This value heavily affects the running time and memory usage" as ***Attention*** shown. Same as the above, please use the ***Number of Runs*** textbox to enter the number of runs in a design. After you finish the above inputs, please click the ***Generate*** button to process the FIRSF procedure.




- After you click the ***Generate*** button, please click the ***IRSF*** tab to check the result. There are two parts showing at the top of this page, the ***Pareto Front Plot*** (left) and the ***Criterion Table*** (right). In the ***Pareto Front Plot*** part, you can click the points in the plot to get the specific design table as following.

Design table

| x1 | x2 | x3 | y1 |
|---|---|---|---|
| 0.11 | 0.11 | 0.11 | 17.98 |
| 0.67 | 0.22 | 0.00 | 18.81 |
| 0.44 | 0.89 | 0.00 | 18.18 |
| 0.78 | 0.56 | 0.33 | 6.09 |
| 0.22 | 0.67 | 0.78 | 7.81 |
| 0.22 | 0.11 | 0.78 | 13.44 |
| 0.78 | 0.22 | 0.89 | 16.21 |
| 0.22 | 0.11 | 1.00 | 29.48 |
| 0.78 | 1.00 | 0.89 | 18.28 |
| 0.22 | 0.78 | 1.00 | 23.83 |

- For some special cases (1d input and 1d response; 2d input and 1d response; 3d input and 1d response; 2d input and 2d response), you can also get the related plot at the bottom of this page. Here we give an example for a 3-dimensional input space and 1-dimensional response space case as following. You can also right-click the plot to save or copy the image.

Design table

| x1 | x2 | x3 | y1 |
|---|---|---|---|
| 0.11 | 0.11 | 0.11 | 17.98 |
| 0.67 | 0.22 | 0.00 | 18.81 |
| 0.44 | 0.89 | 0.00 | 18.18 |
| 0.78 | 0.56 | 0.33 | 6.09 |
| 0.22 | 0.67 | 0.78 | 7.81 |
| 0.22 | 0.11 | 0.78 | 13.44 |
| 0.78 | 0.22 | 0.89 | 16.21 |
| 0.22 | 0.11 | 1.00 | 29.48 |
| 0.78 | 1.00 | 0.89 | 18.28 |
| 0.22 | 0.78 | 1.00 | 23.83 |