Multi-Objective Optimization Json Format

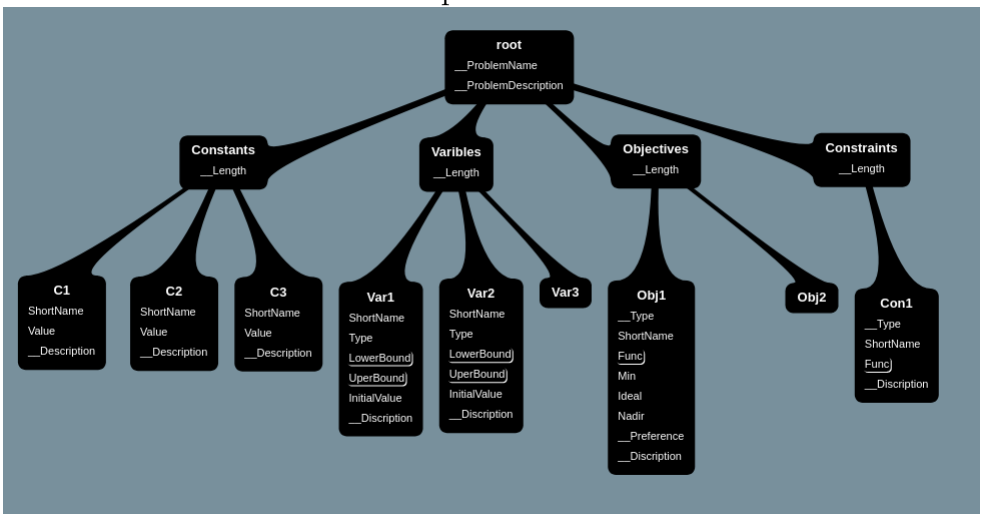
Naming

The naming tradition follows CortexJs which is CamelCase. All the Key word are string varibles, and string start with Capital letter. Note that all keywords are manditory except the keywords start with double underlines "__", e.g. "__Description". if a value is a list, the server will automatically parse it as function.

Structure

Our Json format consists of 4 nodes in general each node has attribute of additional information about numbers of elements inside the node.

The Structure will look like picture below



1. Constants: In Multi-objective optimization problem, Constants are needed sometime, for example user want to defined $Pi == 3.14$ to eliminate

the complexity of calculation. but the key is not manditory, the value can be null.

2. Varibles: Since the Objective fucntion and constraint function are base on it, Varibles are most important things that need to notice. each varible consists of type and keep in mind, it is not optional. Because DESDEO need to know what domain of the varible are to process further optimization.

3. Objectives: Objectives catergory is where the multiobjective optimization problem defined.

4. Constraints: Constraints can be null. It consists of specific constraints with keywords "Con" + number, each constraint has shortname for convience and server call it.

A Simple Tutorial

As an example, consider the following multiobjective optimization problem:

$$\begin{aligned} \text{min.} \quad & f_1 = x_1^2 - x_2 \\ & f_2 = x_2^2 - 3x_1 \\ \text{s.t.} \quad & x_1 + x_2 \leq 10 \\ & x_1, x_2 \in [-5, 5] \end{aligned} \tag{1}$$

Json Format

Varibles must be defined before we are going to use them to form our equations.

```
    "Varibles":{
        "Length": 2,
        "Var1":{
            "ShortName":"x1",
            "Type":"RealNumber",
            "LowerBound":-5,
            "UperBound":5,
            "InitialValue":1,
            "__Discription":"This is first varible,
              it present sth "
        },
```

```
        "Var2":{
            "ShortName":"x2",
            "Type":"RealNumber",
            "LowerBound":-5,
            "UperBound":5,
            "InitialValue":1,
            "__Discription":"This is second varible,
                it present sth "
        }
    },
```

The Key word "Varibles" is manditory for it indicate the definition of the desicion varibles in multiobjective optimization problems. Inside the Varibles dictionary: "Length" infer the number of varibles, and individual varibles start with "Var" + number; each individual varibles has 5 propertities and they are usually defined according to specific problems.

```
    "Objectives":{
        "Length":2,
        "Obj1":{
            "ShortName":"f1",
            "Func":["Substract",["Square","x1"],"x2"
              ],
            "Min": true,
            "Ideal":0,
            "Nadir":10,
            "__Preference":8,
            "__Discription":"This is first objective
              , is present sth"
        },
        "Obj2":{
            "ShortName":"f2",
            "Func":["Substract",["Square","x2"],["
              Multiply",3,"x1"]],
            "Min": true,
            "Ideal":0,
            "Nadir":10,
            "__Preference":6,
            "__Discription":"This is second
              objective, is present sth"
        }
    },
```

```
    "Constraints":{
        "Con1":{
            "ShortName":"g1",
            "Func":["Substract",["Add","x1","x2"], 10]
        }
    },
    "__ProblemName":"name",
    "__ProblemDescription":"This problem is from DESDEO example Analytical problem on https://desdeo-problem.readthedocs.io/en/latest/notebooks/analytical_problem.html"
```

with predifined varibles, we are now able to use thoes varibles to form our multiobjective optimization problems. Note that in "Func", the format is strictly follow the Math Json Format

A Complete Example

Four bar truss design problem

```
{
    "Constants":{
        "Length":5,
        "C1":{
            "ShortName":"F",
            "Value":10,
            "__Discription":"Force, unit: kN"
        },
        "C2":{
            "ShortName":"E",
            "Value":2e5,
            "__Discription":"Energe, unit: kN/cm^2"
        },
        "C3":{
            "ShortName":"L",
            "Value":200,
            "__Discription":"Length, unit: cm"
        },
```

```
            "C4":{
                "ShortName":"sigma",
                "Value":10,
                "__Discription":"Length, unit: kN/cm
                    ^2"
            },
            "C5":{
                "ShortName":"a",
                "Valule":["Divide","F","sigma"],
                "__Discription":"use for Variable
                    bounds "
            }
        },
        "Varibles":{
            "Length": 4,
            "Var1":{
                "ShortName":"x1",
                "Type":"RealNumber",
                "LowerBound":["a"],
                "UperBound":["Multiply",3,"a"],
                "InitialValue":null,
                "__Discription":"This is first
                    varible, it present sth "
            },
            "Var2":{
                "ShortName":"x2",
                "Type":"RealNumber",
                "LowerBound":["Multiply",["Sqrt",2],
                    "a"],
                "UperBound":["Multiply",3,"a"],
                "InitialValue":null,
                "__Discription":"This is second
                    varible, it present sth "
            },
            "Var3":{
                "ShortName":"x3",
                "Type":"RealNumber",
                "LowerBound":["Multiply",["Sqrt",2],
                    "a"],
                "UperBound":["Multiply",3,"a"],
                "InitialValue":null
```

```
            },
            "Var4":{
                "ShortName":"x4",
                "Type":"RealNumber",
                "LowerBound":["a"],
                "UperBound":["Multiply",3,"a"],
                "InitialValue":null
            }
        },
        "Objectives":{
            "Length":2,
            "Obj1":{
                "ShortName":"f1",
                "Func":[
                    [
                      "Multiply",
                      "L",
                      [
                        "Add",
                        ["Multiply", ["Sqrt", 2], "
                           x_2"],
                        ["Multiply", 2, "x_1"],
                        ["Sqrt", "x_3"],
                        "x_4"
                      ]
                    ]
                  ],
                "Min": true,
                "Ideal":null,
                "Nadir":null,
                "__Discription":"minimize structural
                    volume"
            },
            "Obj2":{
                "ShortName":"f2",
                "Func":[
                    "Divide",
                    [
                      "Multiply",
                      "F",
                      "L",
```

```
                        [
                          "Add",
                          ["Divide", 2, "x_1"],
                          ["Divide", 2, "x_4"],
                          ["Divide", ["Multiply", 2, [
                             "Sqrt", 2]], "x_2"],
                          ["Divide", ["Multiply", -2,
                             ["Sqrt", 2]], "x_2"]
                        ]
                      ],
                      "E"
                    ],
                  "Min": true,
                  "Ideal":null,
                  "Nadir":null,
                  "__Discription":"minimize the joint
                     displacement"
              }
        },
        "Constraints":null,
        "__ProblemName":"Four bar truss design
           problem",
        "__ProblemDescription":"This problem is from
            DESDEO example Engineering real-world
           test problems on https://desdeo-problem.
           readthedocs.io/en/latest/problems/
           engineering_real_world.html#re-21-four-
           bar-truss-design-problem"
    }
```