A classification based surrogate-assisted evolutionary algorithm for expensive many-objective optimization

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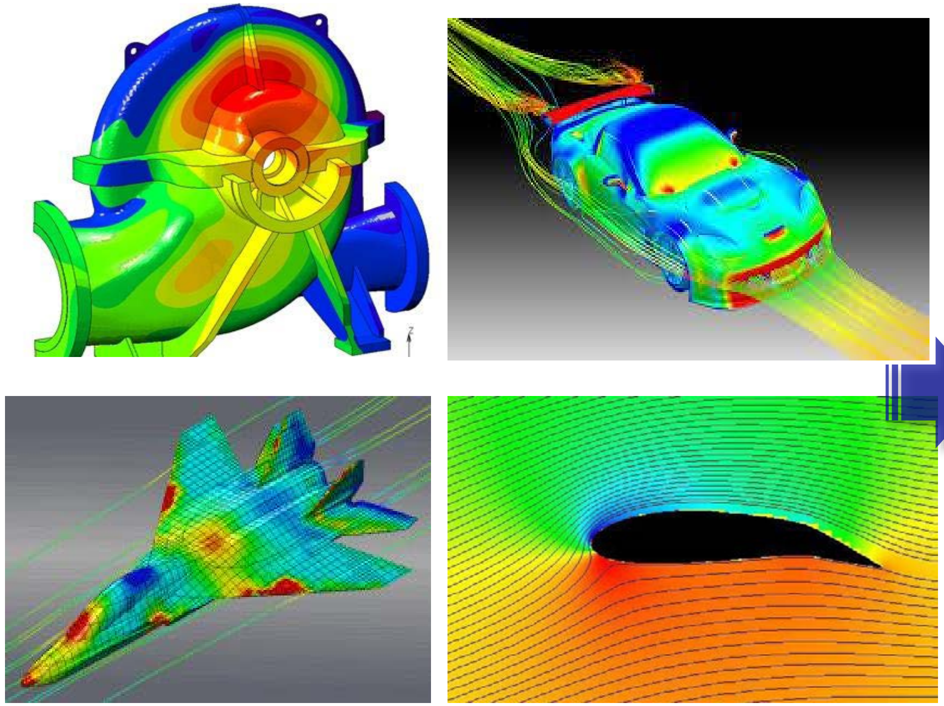
Expensive problems： Computationally and/or Economically Expensive;

Number of function evaluations is limited (*several hundreds*)



CFD simulations

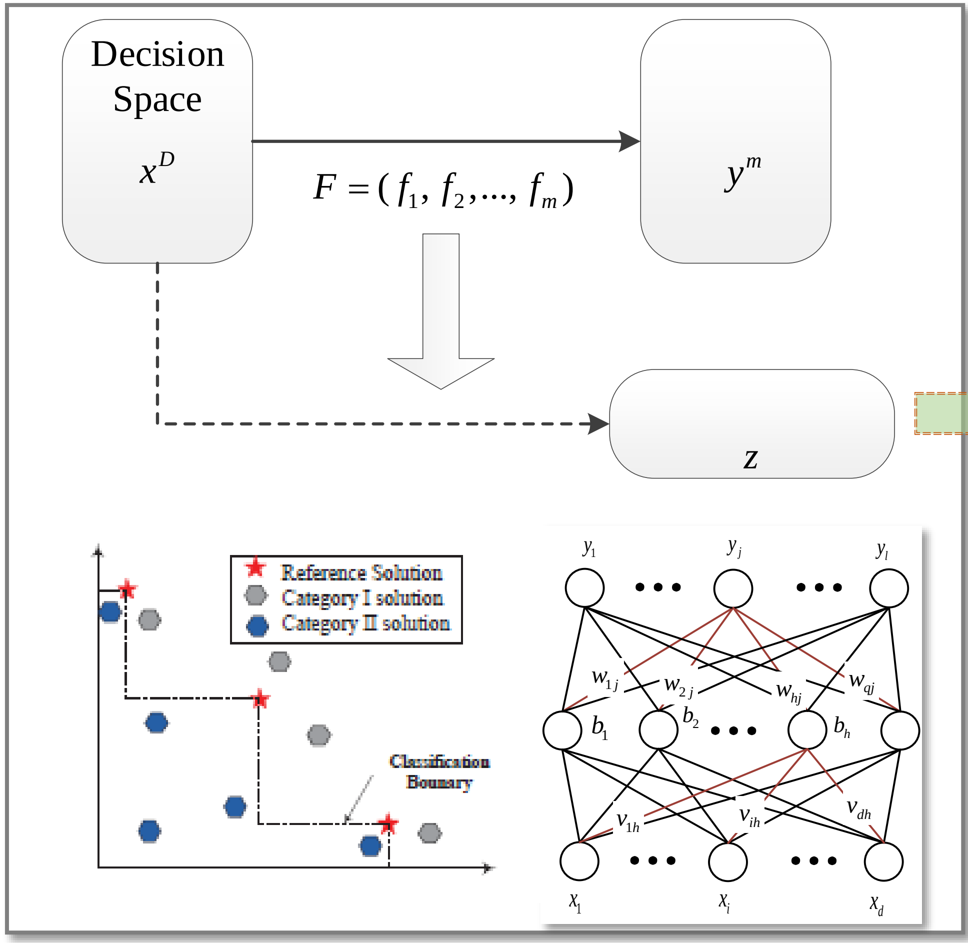
Surrogate-assisted evolutionary algorithm

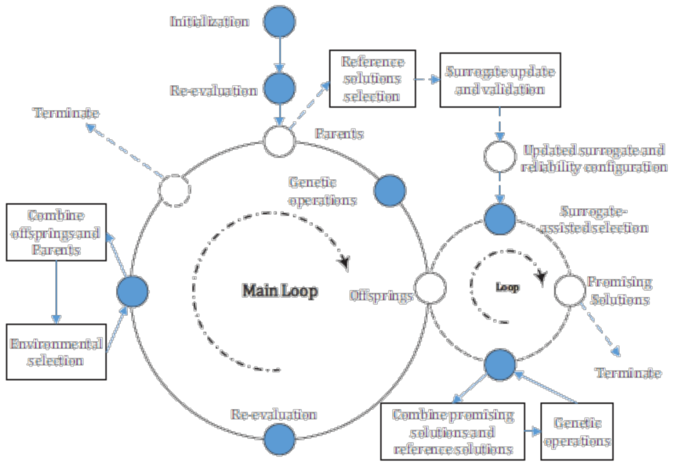
- Surrogate a single objective by a single model (K-RVEA)；
- Surrogate the aggregation/ fitness function (ParEGO、MOEA/D-EGO)
- Surrogate a classifier (CPS-MOEA)

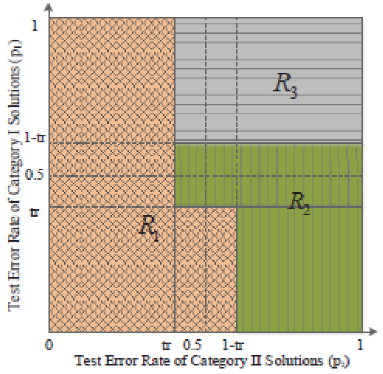
Drawbacks

- Multiple surrogate models are used
- Time consuming

Idea： Design a classification criteria to distinguish good solutions from the bad ones, and then use a neural network to predict the candidate solutions for saving real function evaluations.







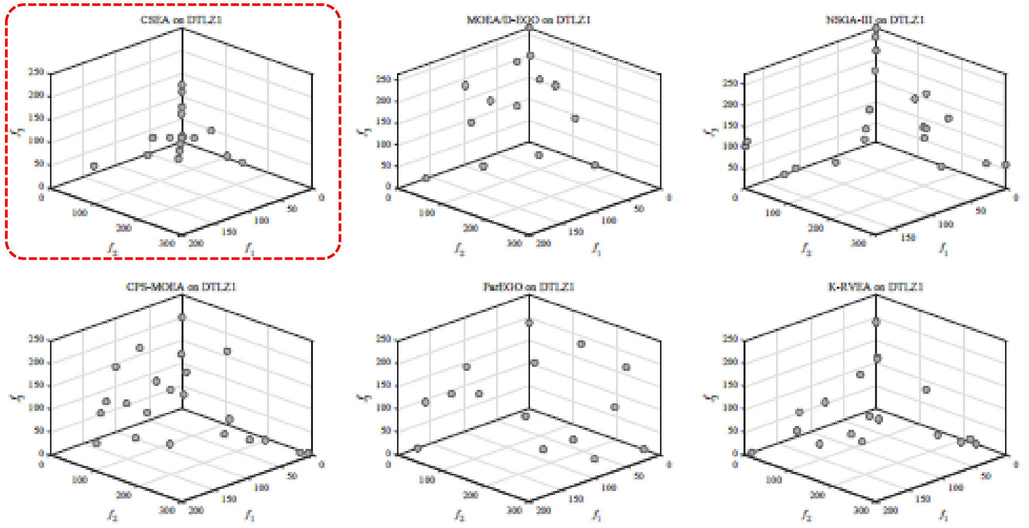
Enhance the prediction accuracy via crossover validation

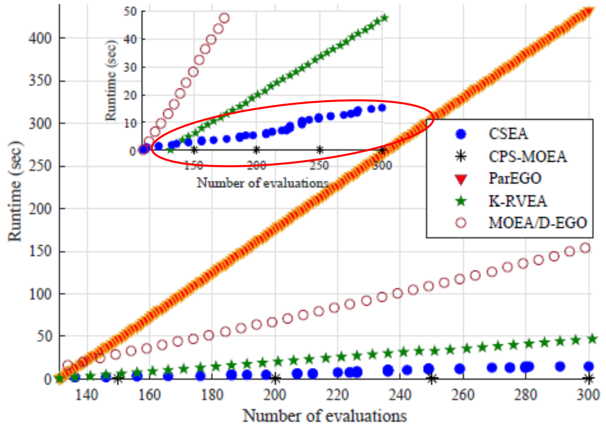
Efficiency of the Surrogate Model

Problem	Obj.	CSEA^-	CSEA
DTLZ1	3	9.71e+1(2.30e+1)–	4.36e+1(8.82e+0)
	6	2.58e+1(1.11e+1)–	1.32e+1(4.43e+0)
	10	3.87e-1(7.15e-2)–	2.86e-1(4.37e-2)
DTLZ3	3	2.47e+2(5.91e+1)–	1.09e+2(2.73e+1)
	6	1.05e+2(2.60e+1)–	4.78e+1(1.38e+1)
	10	1.26e+0(2.49e-1)–	1.00e+0(9.63e-2)
DTLZ5	3	2.21e-1(3.21e-2)–	8.07e-2(2.22e-2)
	6	1.13e-1(1.90e-2)–	6.53e-2(2.20e-2)
	10	8.36e-2(2.96e-2)–	1.00e-2(9.22e-4)
WFG1	4	2.57e+0(8.83e-2)–	**2.01e+0(3.85e-2)**
	6	2.90e+0(7.55e-2)–	**2.51e+0(3.70e-2)**
	8	3.30e+0(1.46e-1)–	**3.00e+0(7.49e-2)**
	10	3.64e+0(1.64e-1)–	**3.30e+0(8.82e-2)**
WFG2	4	8.94e-1(4.72e-2)–	**7.13e-1(5.16e-2)**
	6	1.34e+0(6.26e-2)–	**1.16e+0(1.33e-1)**
	8	1.93e+0(1.82e-1)–	**1.33e+0(1.12e-1)**
	10	2.96e+0(5.76e-1)–	**2.48e+0(2.47e-1)**
WFG3	4	6.90e-1(5.21e-2)–	**5.14e-1(6.39e-2)**
	6	8.49e-1(7.02e-2)–	**6.44e-1(3.48e-2)**
	8	8.96e-1(7.71e-2)–	**6.87e-1(7.08e-2)**
	10	7.55e-1(8.98e-2)–	**5.24e-1(6.86e-2)**
WFG4	4	1.28e+0(1.42e-1)–	**9.03e-1(6.51e-2)**
	6	3.32e+0(2.65e-1)–	**2.65e+0(2.62e-1)**
	8	6.30e+0(2.77e-1)–	**5.00e+0(3.98e-1)**
	10	1.01e+1(7.53e-1)–	**8.74e+0(5.93e-1)**
WFG5	4	1.12e+0(3.48e-2)–	**8.74e-1(1.38e-2)**
	6	2.69e+0(1.76e-1)–	**2.11e+0(7.87e-2)**
	8	5.02e+0(3.18e-1)–	**4.00e+0(1.27e-1)**
	10	8.01e+0(4.72e-1)–	**7.08e+0(2.50e-1)**
WFG6	4	1.22e+0(4.51e-2)–	**1.06e+0(3.05e-2)**
	6	2.92e+0(1.76e-1)–	**2.37e+0(1.07e-1)**
	8	5.25e+0(3.73e-1)–	**4.01e+0(2.19e-1)**
	10	8.00e+0(4.10e-1)–	**7.12e+0(2.79e-1)**
WFG7	4	1.11e+0(7.51e-2)–	**9.14e-1(2.36e-2)**
	6	2.87e+0(2.05e-1)–	**2.40e+0(2.01e-1)**
	8	5.62e+0(3.86e-1)–	**4.64e+0(2.34e-1)**
	10	8.70e+0(4.21e-1)–	**7.52e+0(3.79e-1)**
WFG8	4	1.45e+0(7.24e-2)–	**1.21e+0(7.30e-2)**
	6	3.23e+0(2.47e-1)–	**2.76e+0(1.33e-1)**
	8	5.62e+0(4.57e-1)–	**4.90e+0(3.61e-1)**
	10	8.89e+0(4.82e-1)–	**8.07e+0(3.62e-1)**
WFG9	4	1.27e+0(1.25e-1)–	**1.08e+0(4.29e-2)**
	6	2.97e+0(2.23e-1)–	**2.46e+0(1.15e-1)**
	8	5.38e+0(3.42e-1)–	**4.46e+0(1.91e-1)**
	10	8.09e+0(4.47e-1)–	**7.16e+0(4.44e-1)**

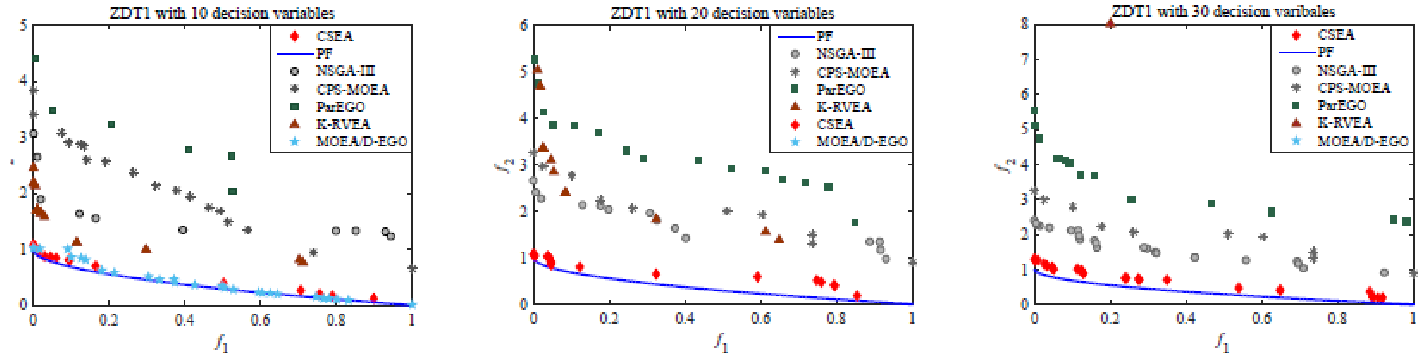
Significant Performance Improvement

Performance on DTLZ1 within 300 FEs





Computation Time



Performance on ZDT1 with 10, 20, and 30 decision variables

Advantages: diversity maintenance, convergence enhancement, computationally efficiency, and ability on problems with up to 30 variables

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