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Multi-objective optimization

Define Pareto efficiency

To solve multi-object optimization problem, we use Pareto efficiency to identify which point is much better. In the beginning, we have to understand these meaning.

Let f : n → and x Ω be given. For the optimization problem
min f(x), s.t. x ∈ Ω

a point x* Ω is called a Pareto minimizer if there exists no x Ω such that for i = 1, 2,…,l. $f_i(x) \leq f_i(x^*)$, and for at least one i, $f_i(x) < f_i(x^*)$.

Pareto domination: x dominate x*, for all f(x) ≤ f(x*)

Pareto optimal point: The point which is solution can dominate at least one other point.

Pareto optimal set: It definition is the same with Pareto optimal point.

Pareto front: f(Pareto optimal set) and it's the vector.

Question 2

Construct a multi-objective optimization problem (MOP) by defining objective functions and the constraint set. Find the associated Pareto front.

$f_1 = x$, $f_2 = -x + y$, f = (f1, f2), find the minimizer.
Subject to for all x and y is integer, $2 \leq x \leq 5, 0 \leq y \leq 5$.

Table I show us all the function value.

Table I function value

(x,y)	f(x,y)	(x,y)	f(x,y)	(x,y)	f(x,y)	(x,y)	f(x,y)
(2,0)	(2,-2)	(3,0)	(3,-3)	(4,0)	(4,-4)	(5,0)	(5,-5)
(2,1)	(2,-1)	(3,1)	(3,-2)	(4,1)	(4,-3)	(5,1)	(5,-4)
(2,2)	(2,0)	(3,2)	(3,-1)	(4,2)	(4,-2)	(5,2)	(5,-3)
(2,3)	(2,1)	(3,3)	(3,0)	(4,3)	(4,-1)	(5,3)	(5,-2)
(2,4)	(2,2)	(3,4)	(3,1)	(4,4)	(4,0)	(5,4)	(5,-1)
(2,5)	(2,3)	(3,5)	(3,2)	(4,5)	(4,1)	(5,5)	(5,0)

By definition, the Pereto set is shown in Table II,

Table II Pereto Set

(x,y)	f(x,y)
(2,0)	(2,-2)
(3,0)	(3,-3)
(4,0)	(4,-4)
(5,0)	(5,-5)

Figure 1 presents function values by blue nodes, Pereto front is pink line which is Pereto sets are connected with each other.

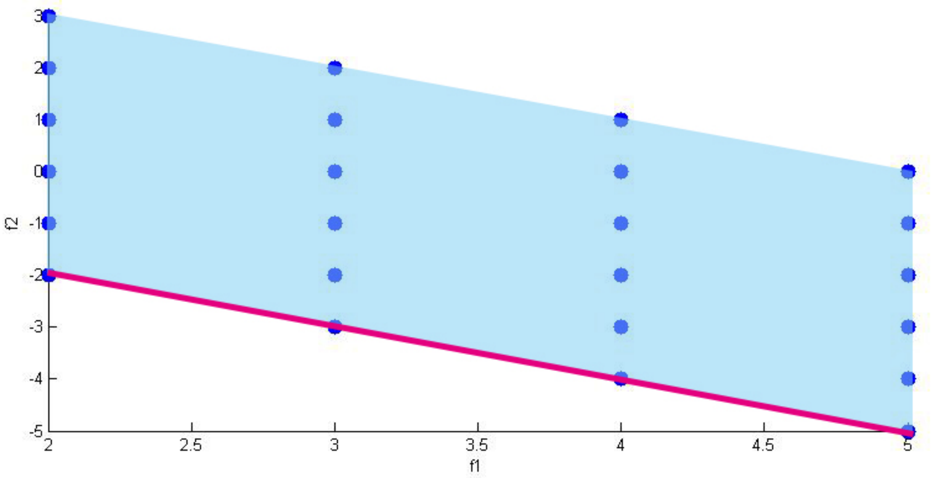

Figure 1 output of question2

- ## Question3

Use HMODE (codes can be downloaded from my website) to solve two algebraic MOPs.

I used this equation to be my example by HMODE.

$f_1 = x$, $f_2 = -(x^2 + y^2)$, $f = (f1, f2)$, find the minimizer.

Subject to for all x and y is integer, $2 \leq x \leq 5, 0 \leq y \leq 5$.

→main.m

```
Np=50;              % size of population
tmax=200;            % # of iteration
eta_c=0.2;           % crossover
max_range=[5 5];
min_range=[2 0];
cstInd=1;  % indicator for constrants; cstInd=1 => inequality constraint
is involved

[EP_alpha, EP_f, num_obj_eval]=
HMODE(Np,tmax,eta_c,min_range,max_range,cstInd);

plot(EP_f(:,1),EP_f(:,2),'or')
xlabel('f_1')
ylabel('f_2')
```

→obj_eval.m

```
x=alpha_c(1);
```

```
y=alpha_c(2);
myobj(1)= x;
myobj(2)= -(x^2+y^2);
g1= -1;
g2= -1;
myobj(3)=max([g1 0])+max([g2 0]);
```

→ plot the integer value

```
for x = 2:1:5
    for y = 0:1:5
        f1 = x;
        f2 = -(x^2+y^2);
        plot(f1,f2,'o');
    end
end
```

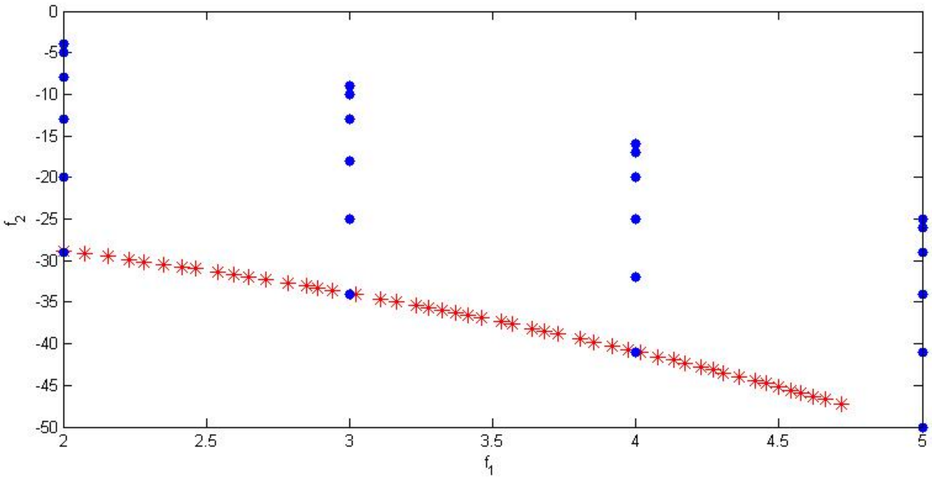

Figure 2 output of question3

We can see Pareto front as red line in Figure 2.