

## MATLAB Tutorial Session #1

MTM4502-Optimization Techniques

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### Main Task

Write a MATLAB program to find the minimum of the function

$$f(\mathbf{x}) = 0.25x_1^4 - 0.5x_1^2 + 0.1x_1 + 0.5x_2^2$$

subject to  $-2 \leq x_i \leq 2$ , for  $i = 1, 2$ , by using Newton-Raphson and Hestenes-Stiefel algorithms. Repeat the main steps of your algorithms until the desired accuracy is achieved, i.e.

$$\|\nabla f(\mathbf{x}_k)\| \leq \epsilon \text{ (or } |f(\mathbf{x}_{k+1}) - f(\mathbf{x}_k)| \leq \epsilon).$$

Take the initial guess as  $\mathbf{x}_0 = [-1 \ 1]^\top$  and absolute error bound as  $\epsilon = 10^{-4}$  for every algorithm. The global minimum is located at  $\mathbf{x}^* = [-1.0465 \ 0]^\top$ ,  $f(\mathbf{x}^*) \approx -0.3523$ . You may see sample realizations of these algorithms as the following.

Newton–Raphson Algorithm

k=1, x1=-1.000000, x2=1.000000, f(x)=0.150000

k=2, x1=-1.050000, x2=0.000000, f(x)=-0.352373, **abs. error**=0.502373

...

Elapsed time is ... seconds.

Hestenes–Stiefel Algorithm

k=1, x1=-1.000000, x2=1.000000, f(x)=0.150000

k=2, x1=-1.099000, x2=0.010000, f(x)=-0.349055, **abs. error**=0.499055

...

Elapsed time is ... seconds.

Answer the following questions:

- How many steps does it take to find the minimum of this function with both of these algorithms?
- What are the execution times of these algorithms? Does this make sense?
- Does the convergence depend on the initial conditions? Why?
- Based on the last two questions, what can be the reason for this trade-off?
- Do you expect the same number of steps and execution times, when you change the stopping criterion and the absolute error bound?

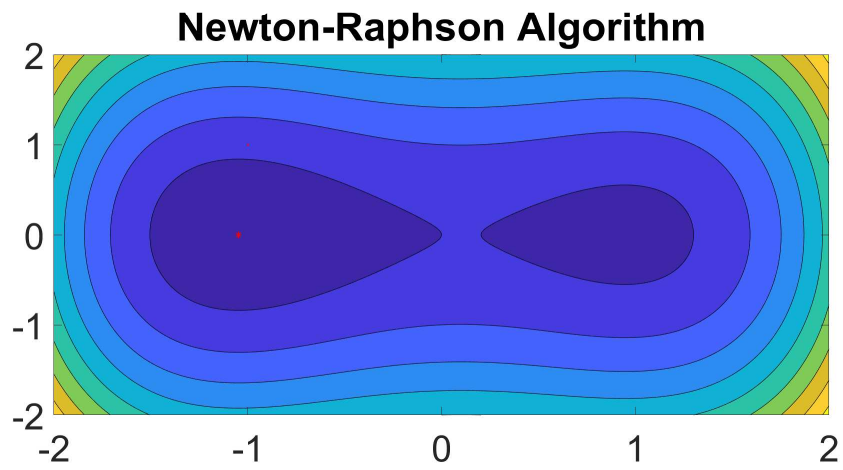


Figure 1: Newton-Raphson Algorithm.

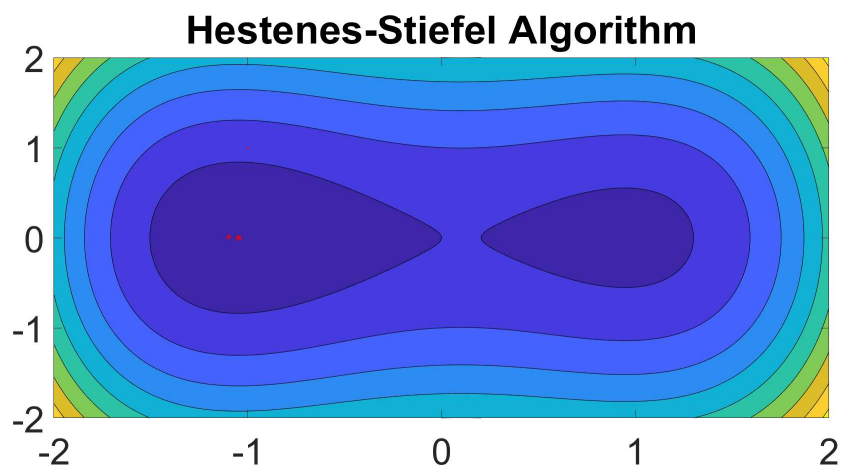


Figure 2: Hestenes-Stiefel Algorithm.