fminsearch

Find minimum of unconstrained multivariable function using derivative-free method

Syntax

```
x = fminsearch(fun,x0)
x = fminsearch(fun,x0,options)
x = fminsearch(problem)
[x,fval] = fminsearch( ___ )
[x,fval,exitflag] = fminsearch( ___ )
[x,fval,exitflag,output] = fminsearch( ___ )
```

Description

Nonlinear programming solver. Searches for the minimum of a problem specified by

$$\min_x f(x)$$

$f(x)$ is a function that returns a scalar, and x is a vector or a matrix; see Matrix Arguments.

`x = fminsearch(fun,x0)` starts at the point `x0` and attempts to find a local minimum `x` of the function described in `fun`. example

`x = fminsearch(fun,x0,options)` minimizes with the optimization options specified in the structure `options`. Use `optimset` to set these options. example

`x = fminsearch(problem)` finds the minimum for `problem`, a structure described in `problem`.

`[x,fval] = fminsearch( ___ )`, for any previous input syntax, returns in `fval` the value of the objective function `fun` at the solution `x`. example

`[x,fval,exitflag] = fminsearch( ___ )` additionally returns a value `exitflag` that describes the exit condition.

`[x,fval,exitflag,output] = fminsearch( ___ )` additionally returns a structure `output` with information about the optimization process. example

Examples

collapse all

Minimize Rosenbrock's Function

Minimize Rosenbrock's function, a notoriously difficult optimization problem for many algorithms:

Try This Example

$$f(x) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2.$$

View MATLAB Command

The function is minimized at the point `x = [1,1]` with minimum value `0`.

Set the start point to `x0 = [-1.2,1]` and minimize Rosenbrock's function using `fminsearch`.

```
fun = @(x)100*(x(2) - x(1)^2)^2 + (1 - x(1))^2;
x0 = [-1.2,1];
x = fminsearch(fun,x0)
```

```
x = 1×2

    1.0000    1.0000
```

Monitor Optimization Process

Set options to monitor the process as `fminsearch` attempts to locate a minimum.

Try This Example

View MATLAB Command

Set options to plot the objective function at each iteration.

```
options = optimset('PlotFcns',@optimplotfval);
```

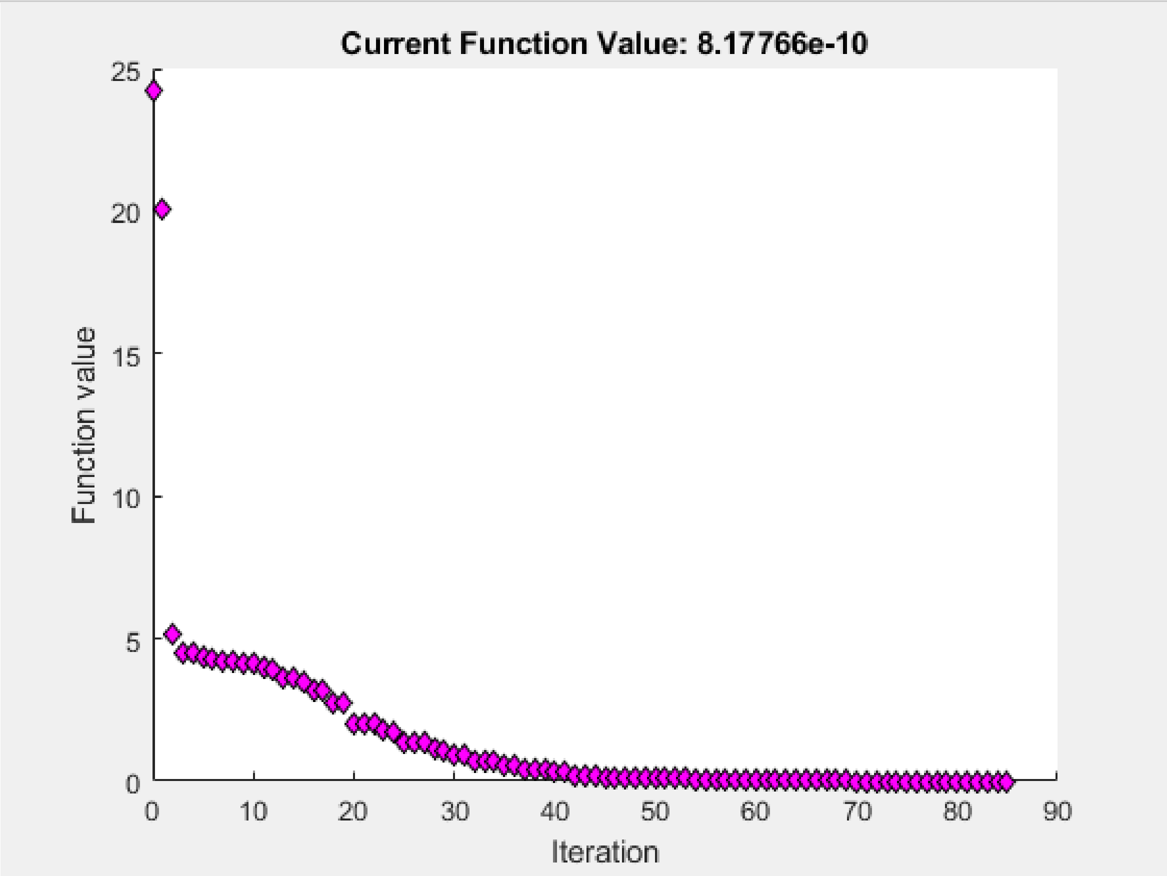
Set the objective function to Rosenbrock's function,

$$f(x) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2.$$

The function is minimized at the point `x = [1,1]` with minimum value `0`.

Set the start point to `x0 = [-1.2,1]` and minimize Rosenbrock's function using `fminsearch`.

```
fun = @(x)100*(x(2) - x(1)^2)^2 + (1 - x(1))^2;
x0 = [-1.2,1];
x = fminsearch(fun,x0,options)
```




```
x = 1×2

    1.0000    1.0000
```

Minimize a Function Specified by a File

View MATLAB Command

Minimize an objective function whose values are given by executing a file. A function file must accept a real vector x and return a real scalar that is the value of the objective function.

Copy the following code and include it as a file named `objectivefcn1.m` on your MATLAB® path.

```
function f = objectivefcn1(x)
f = 0;
for k = -10:10
    f = f + exp(-(x(1)-x(2))^2 - 2*x(1)^2)*cos(x(2))*sin(2*x(2));
end
```

Start at `x0 = [0.25,-0.25]` and search for a minimum of `objectivefcn`.

```
x0 = [0.25,-0.25];
x = fminsearch(@objectivefcn1,x0)
```

```
x =

   -0.1696   -0.5086
```

Minimize with Extra Parameters

Sometimes your objective function has extra parameters. These parameters are not variables to optimize, they are fixed values during the optimization. For example, suppose that you have a parameter a in the Rosenbrock-type function

Try This Example

View MATLAB Command

$$f(x,a) = 100(x_2 - x_1^2)^2 + (a - x_1)^2.$$

This function has a minimum value of 0 at $x_1 = a$, $x_2 = a^2$. If, for example, $a = 3$, you can include the parameter in your objective function by creating an anonymous function.

Create the objective function with its extra parameters as extra arguments.

```
f = @(x,a)100*(x(2) - x(1)^2)^2 + (a-x(1))^2;
```

Put the parameter in your MATLAB® workspace.

```
a = 3;
```

Create an anonymous function of x alone that includes the workspace value of the parameter.

```
fun = @(x)f(x,a);
```

Solve the problem starting at `x0 = [-1,1.9]`.

```
x0 = [-1,1.9];
x = fminsearch(fun,x0)
```

```
x = 1×2

    3.0000    9.0000
```

For more information about using extra parameters in your objective function, see Parameterizing Functions.

Find Minimum Location and Value

Find both the location and value of a minimum of an objective function using `fminsearch`.

Try This Example

Write an anonymous objective function for a three-variable problem. View MATLAB Command

```
x0 = [1,2,3];
fun = @(x)-norm(x+x0)^2*exp(-norm(x-x0)^2 + sum(x));
```

Find the minimum of `fun` starting at `x0`. Find the value of the minimum as well.

```
[x,fval] = fminsearch(fun,x0)
```

```
x = 1×3

    1.5359    2.5645    3.5932

fval = -5.9565e+04
```

Inspect Optimization Process

Inspect the results of an optimization, both while it is running and after it finishes. View MATLAB Command

Set options to provide iterative display, which gives information on the optimization as the solver runs. Also, set a plot function to show the objective function value as the solver runs.

```
options = optimset('Display','iter','PlotFcns',@optimplotfval);
```

Set an objective function and start point.

```
function f = objectivefcn1(x)
f = 0;
for k = -10:10
    f = f + exp(-(x(1)-x(2))^2 - 2*x(1)^2)*cos(x(2))*sin(2*x(2));
end
```

Include the code for `objectivefcn1` as a file on your MATLAB® path.

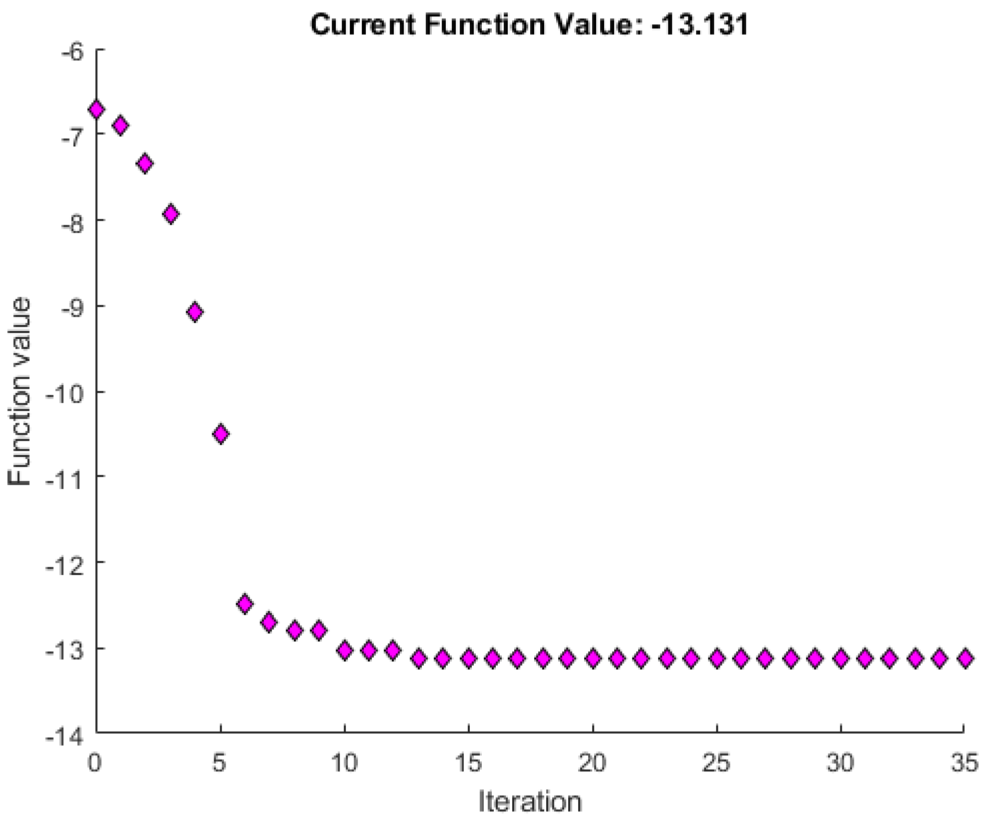
```
x0 = [0.25,-0.25];
fun = @objectivefcn1;
```

Obtain all solver outputs. Use these outputs to inspect the results after the solver finishes.

```
[x,fval,exitflag,output] = fminsearch(fun,x0,options)
```

```
 Iteration   Func-count     min f(x)         Procedure
     0            1         -6.70447         
     1            3         -6.89837         initial simplex
     2            5         -7.34101         expand
     3            7         -7.91894         expand
     4            9         -9.07939         expand
     5           11         -10.5047         expand
     6           13         -12.4957         expand
     7           15         -12.6957         reflect
     8           17         -12.8052         contract outside
     9           19         -12.8052         contract inside
    10           21         -13.0189         expand
    11           23         -13.0189         contract inside
    12           25         -13.0374         reflect
    13           27          -13.122         reflect
```

```
    14           28           -13.122         reflect
    15           29           -13.122         reflect
    16           31           -13.122         contract outside
    17           33          -13.1279         contract inside
    18           35          -13.1279         contract inside
    19           37          -13.1296         contract inside
    20           39          -13.1301         contract inside
    21           41          -13.1305         reflect
    22           43          -13.1306         contract inside
    23           45          -13.1309         contract inside
    24           47          -13.1309         contract inside
    25           49           -13.131         reflect
    26           51           -13.131         contract inside
    27           53           -13.131         contract inside
    28           55           -13.131         contract inside
    29           57           -13.131         contract outside
    30           59           -13.131         contract inside
    31           61           -13.131         contract inside
    32           63           -13.131         contract inside
    33           65           -13.131         contract outside
    34           67           -13.131         contract inside
    35           69           -13.131         contract inside

Optimization terminated:
 the current x satisfies the termination criteria using OPTIONS.TolX of 1.000000e-04
 and F(X) satisfies the convergence criteria using OPTIONS.TolFun of 1.000000e-04


x =

   -0.1696   -0.5086


fval =

  -13.1310


exitflag =

     1


output =

  struct with fields:

    iterations: 35
     funcCount: 69
     algorithm: 'Nelder-Mead simplex direct search'
       message: 'Optimization terminated:...'
```



The value of `exitflag` is `1`, meaning `fminsearch` likely converged to a local minimum.

The `output` structure shows the number of iterations. The iterative display and the plot show this information as well. The `output` structure also shows the number of function evaluations, which the iterative display shows, but the chosen plot function does not.

Input Arguments

collapse all

`fun` — Function to minimize
function handle | function name

Function to minimize, specified as a function handle or function name. `fun` is a function that accepts a vector or array `x` and returns a real scalar `f` (the objective function evaluated at `x`).

`fminsearch` passes `x` to your objective function in the shape of the `x0` argument. For example, if `x0` is a 5-by-3 array, then `fminsearch` passes `x` to `fun` as a 5-by-3 array.

Specify `fun` as a function handle for a file:

```
x = fminsearch(@myfun,x0)
```

where `myfun` is a MATLAB® function such as

```
function f = myfun(x)
f = ...            % Compute function value at x
```

You can also specify `fun` as a function handle for an anonymous function:

```
x = fminsearch(@(x)norm(x)^2,x0);
```

Example: `fun = @(x)-x*exp(-3*x)`

Data Types: `char` | `function_handle` | `string`

x0 — Initial point
real vector | real array

Initial point, specified as a real vector or real array. Solvers use the number of elements in `x0` and the size of `x0` to determine the number and size of variables that `fun` accepts.

Example: `x0 = [1,2,3,4]`

Data Types: `double`

options — Optimization options
structure such as `optimset` returns

Optimization options, specified as a structure such as `optimset` returns. You can use `optimset` to set or change the values of these fields in the options structure. See Optimization Options Reference for detailed information.

`Display`	Level of display (see Iterative Display): • `'notify'` (default) displays output only if the function does not converge. • `'final'` displays just the final output. • `'off'` or `'none'` displays no output. • `'iter'` displays output at each iteration.
`FunValCheck`	Check whether objective function values are valid. `'on'` displays an error when the objective function returns a value that is `complex` or `NaN`. The default `'off'` displays no error.
`MaxFunEvals`	Maximum number of function evaluations allowed, a positive integer. The default is `200*numberOfVariables`. See Tolerances and Stopping Criteria and Iterations and Function Counts.
`MaxIter`	Maximum number of iterations allowed, a positive integer. The default value is `200*numberOfVariables`. See Tolerances and Stopping Criteria and Iterations and Function Counts.
`OutputFcn`	Specify one or more user-defined functions that an optimization function calls at each iteration, either as a function handle or as a cell array of function handles. The default is none (`[]`). See Output Function and Plot Function Syntax.
`PlotFcns`	Plots various measures of progress while the algorithm executes. Select from predefined plots or write your own. Pass a function handle or a cell array of function handles. The default is none (`[]`): • `@optimplotx` plots the current point. • `@optimplotfunccount` plots the function count. • `@optimplotfval` plots the function value. Custom plot functions use the same syntax as output functions. See Output Functions for Optimization Toolbox™ and Output Function and Plot Function Syntax.
`TolFun`	Termination tolerance on the function value, a positive scalar. The default is `1e-4`. See Tolerances and Stopping Criteria. Unlike other solvers, `fminsearch` stops when it satisfies *both* `TolFun` and `TolX`.
`TolX`	Termination tolerance on `x`, a positive scalar. The default value is `1e-4`. See Tolerances and Stopping Criteria. Unlike other solvers, `fminsearch` stops when it satisfies *both* `TolFun` and `TolX`.

Example: `options = optimset('Display','iter')`

Data Types: `struct`

`problem` — **Problem structure**
structure

Problem structure, specified as a structure with the following fields.

Field Name	**Entry**
`objective`	Objective function
`x0`	Initial point for x
`solver`	`'fminsearch'`
`options`	Options structure such as returned by `optimset`

Data Types: `struct`

Output Arguments

collapse all

`x` — **Solution**
real vector | real array

Solution, returned as a real vector or real array. The size of `x` is the same as the size of `x0`. Typically, `x` is a local solution to the problem when `exitflag` is positive. For information on the quality of the solution, see When the Solver Succeeds.

`fval` — **Objective function value at solution**
real number

Objective function value at the solution, returned as a real number. Generally, `fval` = `fun(x)`.

`exitflag` — **Reason `fminsearch` stopped**
integer

Reason `fminsearch` stopped, returned as an integer.

`1`	The function converged to a solution `x`.
`0`	Number of iterations exceeded `options.MaxIter` or number of function evaluations exceeded `options.MaxFunEvals`.
`-1`	The algorithm was terminated by the output function.

`output` — **Information about the optimization process**
structure

Information about the optimization process, returned as a structure with fields:

`iterations`	Number of iterations
`funcCount`	Number of function evaluations
`algorithm`	`'Nelder-Mead simplex direct search'`

message	Exit message

Tips

- fminsearch only minimizes over the real numbers, that is, x must only consist of real numbers and $f(x)$ must only return real numbers. When x has complex values, split x into real and imaginary parts.
- Use fminsearch to solve nondifferentiable problems or problems with discontinuities, particularly if no discontinuity occurs near the solution.
- fminsearch is generally less efficient than fminunc, especially for problems of dimension greater than two. However, when the problem is discontinuous, fminsearch can be more robust than fminunc.
- fminsearch is not the preferred solver for problems that are sums of squares, that is, of the form

  $$\min_x \|f(x)\|_2^2 = \min_x \left(f_1(x)^2 + f_2(x)^2 + \ldots + f_n(x)^2\right)$$

  Instead, use the lsqnonlin function, which has been optimized for problems of this form.

Algorithms

fminsearch uses the simplex search method of Lagarias et al. [1]. This is a direct search method that does not use numerical or analytic gradients as in fminunc. The algorithm is described in detail in fminsearch Algorithm. The algorithm is not guaranteed to converge to a local minimum.

Alternative Functionality

App

The **Optimize** Live Editor task provides a visual interface for fminsearch.

References

[1] Lagarias, J. C., J. A. Reeds, M. H. Wright, and P. E. Wright. “Convergence Properties of the Nelder-Mead Simplex Method in Low Dimensions.” *SIAM Journal of Optimization*. Vol. 9, Number 1, 1998, pp. 112–147.

Extended Capabilities

C/C++ Code Generation
Generate C and C++ code using MATLAB® Coder™.

See Also

fminbnd | fminunc | optimset | Optimize

Topics

Create Function Handle

Anonymous Functions

Introduced before R2006a