fminsearch

Search for local 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 a local minimum of a problem specified by

$f(x)$ is a function that returns a scalar, and x is a vector or array.

For details, see Local vs. Global Minimum.

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

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

`x = fminsearch(problem)` searches for a local minimum for `problem`, where `problem` is a structure.

`[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:

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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)
```

Get

```
x = 1×2

    1.0000    1.0000
```

Monitor Optimization Process

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

Set options to plot the objective function at each iteration.

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

Get

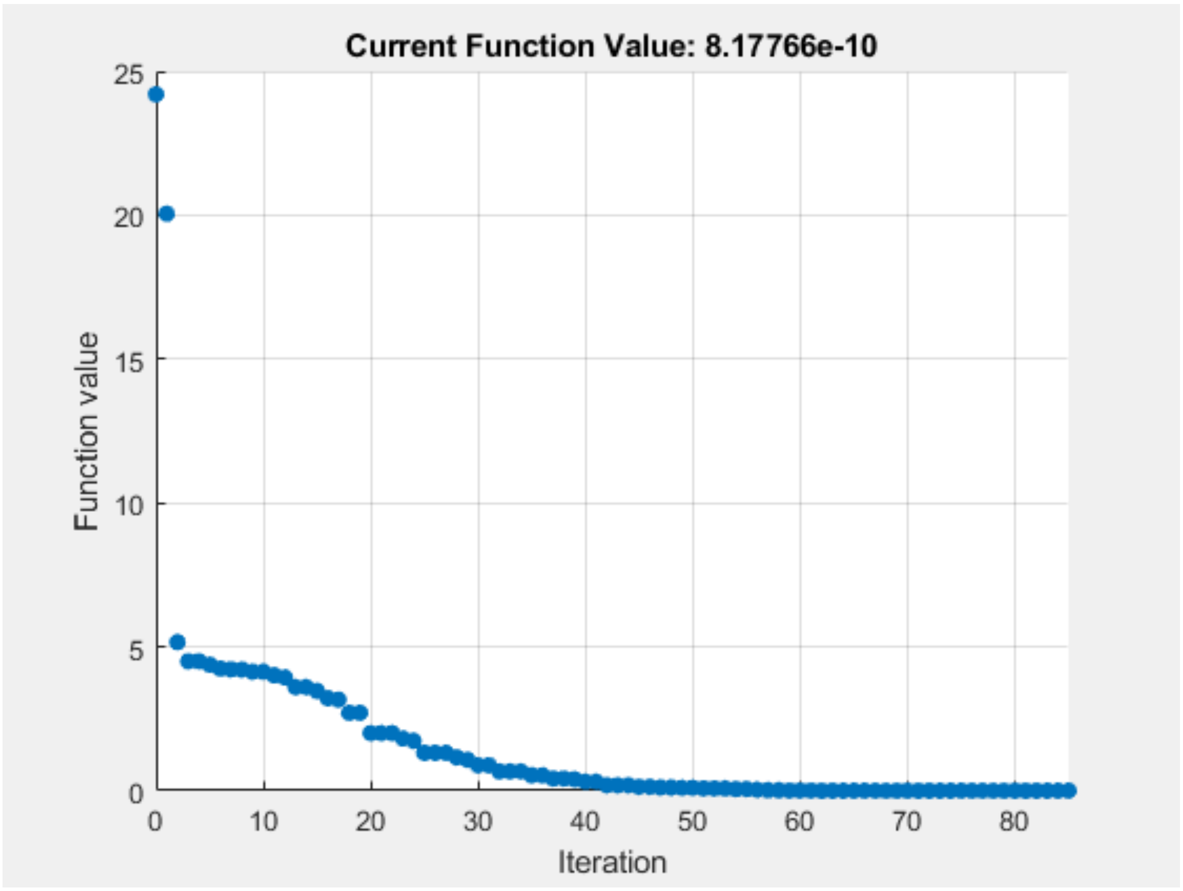
Set the objective function to Rosenbrock's function,

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)
```

Get



```
x = 1×2

    1.0000    1.0000
```

Minimize a Function Specified by a File

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.

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Copy Command

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`.

Get

```
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

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Copy Command

This function has a minimum value of 0 at

,

. If, for example,

, 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`.

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

Copy 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.

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.

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Copy Command

```
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
```

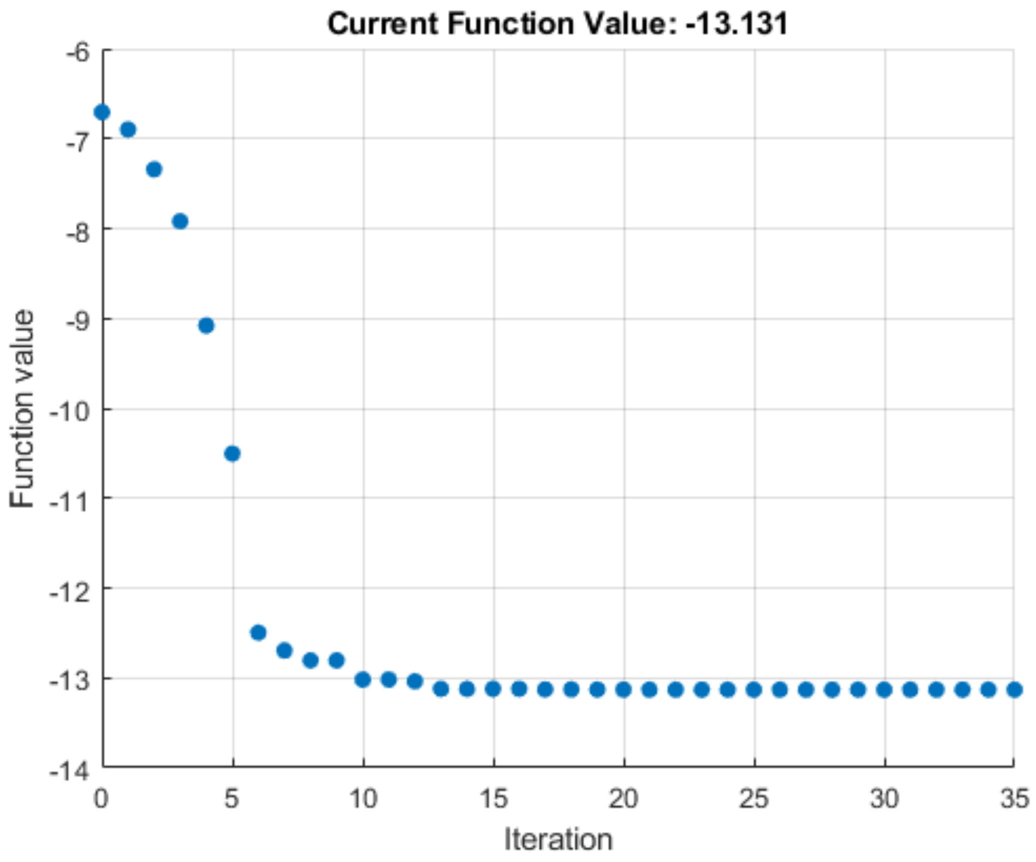
Include the code for `objectivefcn1` as a file on your MATLAB® path.

```
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         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, and 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 Set Optimization Options for detailed information.

`Display`	Level of display (see Optimization Solver 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.
`MaxIter`	Maximum number of iterations allowed, a positive integer. The default value is `200*numberOfVariables`. See Tolerances and Stopping Criteria.
`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 Optimization Solver Output Functions.
`PlotFcns`	Plots various measures of progress while the algorithm executes. Select from predefined plots or write your own. Pass a function name, function handle, or a cell array of function names or handles. The default is none (`[]`): • `@optimplotx` plots the current point. • `@optimplotfunccount` plots the function count. • `@optimplotfval` plots the function value. For information on writing a custom plot function, see Optimization Solver Plot Functions.
`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 an approximate local solution to the problem when exitflag is positive. See Local vs. Global Minimum. However, as stated in Algorithms, the solution x is not guaranteed to be a local minimum.

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

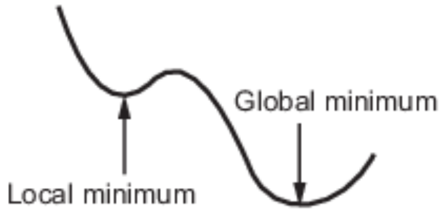
More About

collapse all

Local vs. Global Minimum

In general, optimization solvers return a local minimum (or optimum). The result might be a global minimum (or optimum), but might not.

- A *local* minimum of a function is a point where the function value is smaller than at nearby points, but possibly greater than at a distant point.
- A *global* minimum is a point where the function value is smaller than at all other feasible points.



MATLAB and Optimization Toolbox™ optimization solvers typically return a local minimum. Global Optimization Toolbox solvers can search for a global minimum, but do not guarantee that their solutions are global. For an example of global search, see Find Global or Multiple Local Minima (Global Optimization Toolbox).

Tips

- `fminsearch` only minimizes over the real numbers, that is, the vector or array 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.

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` (Optimization Toolbox). 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™.

› **Thread-Based Environment**
Run code in the background using MATLAB® `backgroundPool` or accelerate code with Parallel Computing Toolbox™ `ThreadPool`.

Version History

Introduced before R2006a

See Also

`fminbnd` | `optimset` | Optimize

Topics

Minimizing Functions of Several Variables

Curve Fitting via Optimization

Create Function Handle

Anonymous Functions