Mínimos locales (`fminunc`) vs. globales (`ga`)

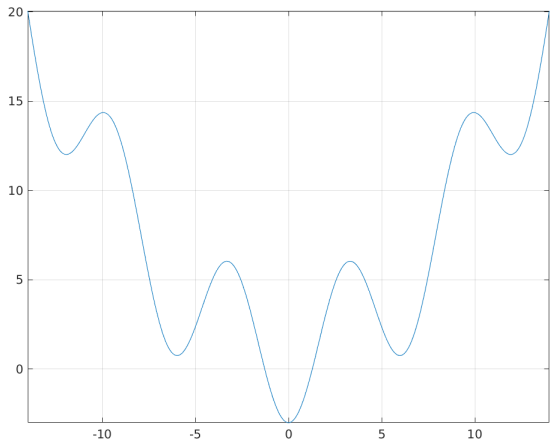
Presentación en vídeo: http://personales.upv.es/asala/YT/V/optimfmga.html

*Este código ejecutó sin errores en Matlab **R2019b**

Objetivo: Comparar la optimización local (gradiente, hessiano, ...) de **`fminunc`** (Optimization Toolbox) con la global de los algoritmos genéticos (**`ga`**, Global Optimization Toolbox) que usan búsqueda aleatoria dirigida.

Función a minimizar:

```
f=@(x) 0.1*x.^2-4*cos(x)+1;
rango_x=-14:.02:14;
plot(rango_x,f(rango_x)), grid on, axis tight
```



Optimización local

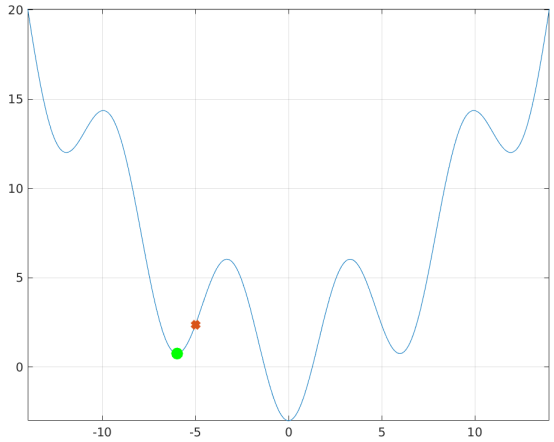
```
x_inicial=-5;
tic, xopt=fminunc(f,x_inicial), toc
```

```
Local minimum found.

Optimization completed because the size of the gradient is less than
the value of the optimality tolerance.

<stopping criteria details>
xopt = -5.9796
Elapsed time is 0.001716 seconds.
```

```
plot(rango_x,f(rango_x)), grid on, axis tight, hold on
plot(x_inicial,f(x_inicial),'x','LineWidth',12), plot(xopt,f(xopt),'og','LineWidth',9),
```




```
x_inicial=1
```

```
x_inicial = 1
```

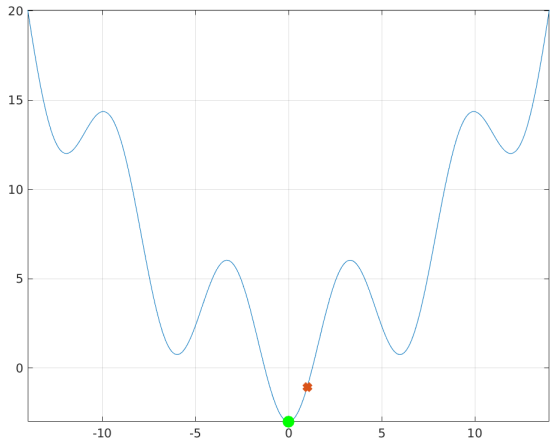
```
tic, xopt2=fminunc(f,x_inicial), toc
```

```
Local minimum found.

Optimization completed because the size of the gradient is less than
the value of the optimality tolerance.

<stopping criteria details>
xopt2 = 0
Elapsed time is 0.001253 seconds.
```

```
plot(rango_x,f(rango_x)), grid on, axis tight, hold on
plot(x_inicial,f(x_inicial),'x','LineWidth',12), plot(xopt2,f(xopt2),'og','LineWidth',9
```



Optimización global

```
x_min=-8; x_max=8; %zona de búsqueda
opts=optimoptions('ga','MaxTime',120,'FunctionTolerance',5e-4,'Display','iter');
% dos minutos máximo tiempo de ejecución (aprox.)
```

```
NumParamsAOptimizar=1;
tic
[xopt_ga]=ga(f, NumParamsAOptimizar,[],[],[],[],x_min,x_max,[],opts)
```

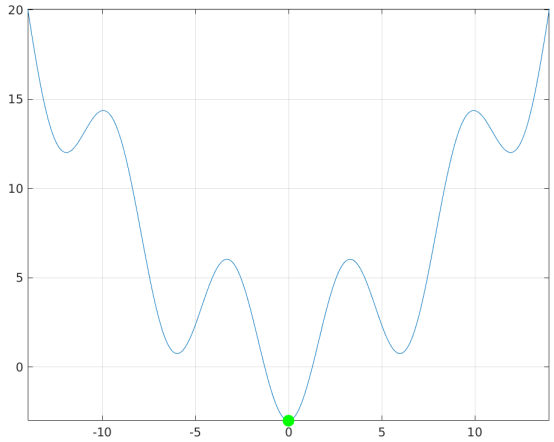
```
                                Best           Mean      Stall
Generation      Func-count       f(x)           f(x)    Generations
    1              100          -2.998           1.82        0
    2              147          -2.998         0.5758        1
    3              194          -2.998        -0.3155        2
    4              241          -2.998         -1.363        3
    5              288          -2.998          -2.11        4
    6              335          -2.998         -2.571        0
    7              382          -2.998          -2.89        1
    8              429          -2.998         -2.894        2
    9              476              -3         -2.994        0
   10              523              -3         -2.993        1
   11              570              -3         -2.994        2
   12              617              -3         -2.995        3
   13              664              -3         -2.996        4
   14              711              -3         -2.999        0
   15              758              -3             -3        1
   16              805              -3             -3        0
   17              852              -3             -3        1
   18              899              -3             -3        2
   19              946              -3             -3        3
   20              993              -3             -3        4
   21             1040              -3             -3        5
   22             1087              -3             -3        6
   23             1134              -3             -3        0
   24             1181              -3             -3        1
   25             1228              -3             -3        2
   26             1275              -3             -3        3
   27             1322              -3             -3        4
   28             1369              -3             -3        5
   29             1416              -3             -3        6
   30             1463              -3             -3        7

                                Best           Mean      Stall
Generation      Func-count       f(x)           f(x)    Generations
   31             1510              -3             -3        8
   32             1557              -3             -3        9
   33             1604              -3             -3       10
   34             1651              -3             -3       11
   35             1698              -3             -3       12
   36             1745              -3             -3       13
   37             1792              -3             -3       14
   38             1839              -3             -3       15
   39             1886              -3             -3       16
   40             1933              -3             -3       17
   41             1980              -3             -3       18
   42             2027              -3             -3       19
   43             2074              -3             -3       20
   44             2121              -3             -3       21
   45             2168              -3             -3       22
   46             2215              -3             -3       23
   47             2262              -3             -3       24
   48             2309              -3             -3       25
   49             2356              -3             -3       26
   50             2403              -3             -3       27
   51             2450              -3             -3       28
Optimization terminated: average change in the fitness value less than options.FunctionTolerance.
xopt_ga = -7.5282e-06
```

```
toc
```

```
Elapsed time is 0.029092 seconds.
```

```
plot(rango_x,f(rango_x)), grid on, axis tight, hold on
plot(xopt_ga,f(xopt_ga),'og','LineWidth',9),hold off
```



Opción intermedia: multistart

```
F_MejorPorAhora=1e9;
xopt=NaN;
for i=1:6
    x_inicial=rand()*(x_max-x_min)+x_min;
    [xopt_tmp,fval]=fminunc(f,x_inicial);
    if(fval<F_MejorPorAhora)
        xopt=xopt_tmp;
        F_MejorPorAhora=fval;
    end
end
```

```
Local minimum found.

Optimization completed because the size of the gradient is less than
the value of the optimality tolerance.

<stopping criteria details>

Local minimum found.

Optimization completed because the size of the gradient is less than
the value of the optimality tolerance.

<stopping criteria details>

Local minimum found.

Optimization completed because the size of the gradient is less than
the value of the optimality tolerance.

<stopping criteria details>
```

```
Local minimum found.

Optimization completed because the size of the gradient is less than
the value of the optimality tolerance.

<stopping criteria details>

Local minimum found.

Optimization completed because the size of the gradient is less than
the value of the optimality tolerance.

<stopping criteria details>

Local minimum found.

Optimization completed because the size of the gradient is less than
the value of the optimality tolerance.

<stopping criteria details>
```

```
xopt
```

```
xopt = -2.9814e-09
```

```
F_MejorPorAhora
```

```
F_MejorPorAhora = -3
```

Conclusiones

La optimización "local" es más rápida pero su resultado puede ser subóptimo. La búsqueda global tiene más probabilidades de obtener el óptimo global, pero es costosa computacionalmente si el número de parámetros a buscar es elevado.