

# Johns Hopkins Engineering

## Applied Machine Learning for Mechanical Engineers

Optimization, Part 2, E



JOHNS HOPKINS  
WHITING SCHOOL  
*of* ENGINEERING

# Introduction to Genetic Programming in MATLAB

- By the end of this lecture you will be able to:
  - Describe “ga” package in MATLAB
  - Implement “ga” in MATLAB

# Introduction to Genetic Programming in MATLAB

- Formal linear/nonlinear optimization problem with one objective function

$$\begin{aligned} & \text{minimize } f(\mathbf{x}) \\ \text{subject to } & \begin{cases} g_j(\mathbf{x}) \leq 0 & j \in \{1, 2, \dots, J\} \\ h_k(\mathbf{x}) = 0 & k \in \{1, 2, \dots, K\} \end{cases} \quad (2-5) \end{aligned}$$

# Introduction to Genetic Programming in MATLAB

- Genetic programming (linear/nonlinear)

$$\begin{aligned} & \text{minimize } f(\mathbf{x}) \\ \text{subject to } & \begin{cases} g_j(\mathbf{x}) \leq 0 \\ h_k(\mathbf{x}) = 0 \\ \mathbf{G} \cdot \mathbf{x} \leq \mathbf{A} \\ \mathbf{H} \cdot \mathbf{x} = \mathbf{B} \\ \mathbf{L} \leq \mathbf{x} \leq \mathbf{U} \\ \hat{\mathbf{x}}: \hat{x}_l \in \mathbf{x} \end{cases} \quad (2-6) \end{aligned}$$

where  $\hat{\mathbf{x}}$  is a list of integer variables

# Introduction to Genetic Programming in MATLAB

- MATLAB genetic programming

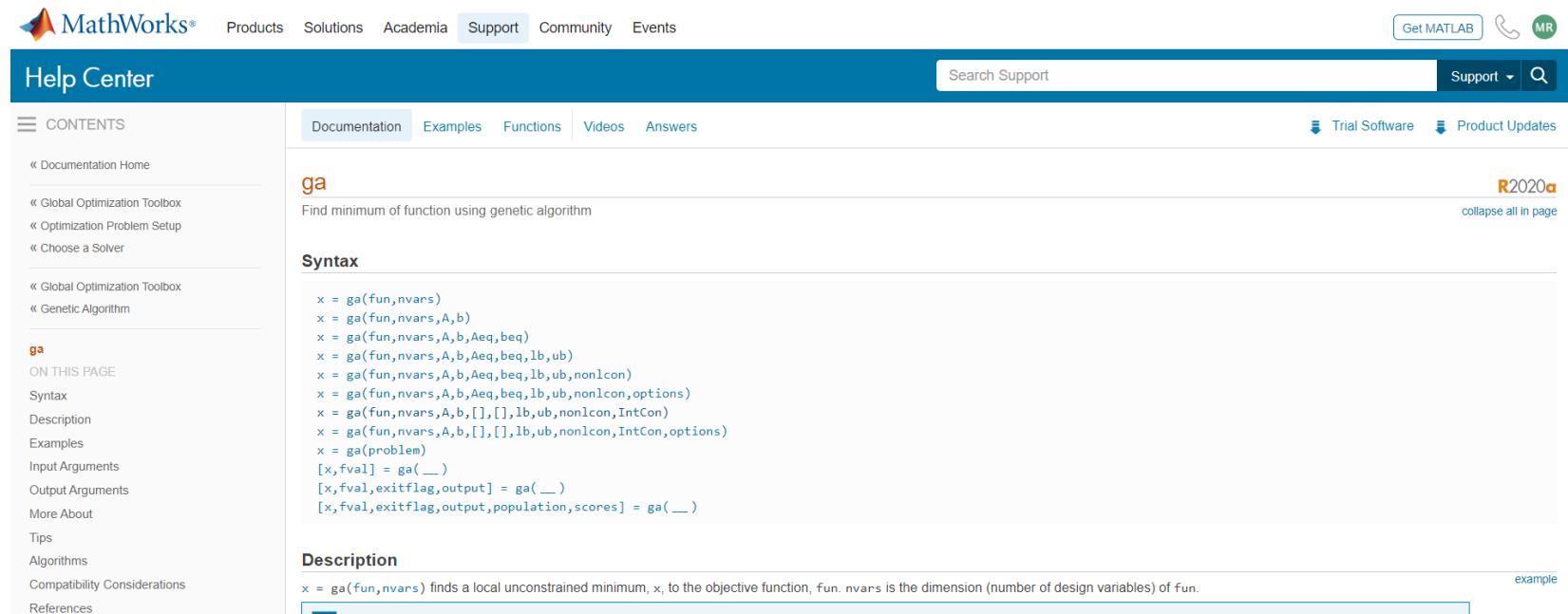
- Different annotations

$$\min f(x) \text{ such that } \begin{cases} c(x) \leq 0 \\ ceq \leq 0 \\ A \cdot x \leq 0 \\ Aeq \cdot x = beq \\ lb \leq x \leq ub \\ IntCon \end{cases}$$

Figure 2-3 Annotations used to address genetic optimization problems at  
<https://www.mathworks.com/help/gads/ga.html>

# Introduction to Genetic Programming in MATLAB

## ■ MATLAB genetic programming ('ga' function)



The screenshot shows the MathWorks Help Center for the 'ga' function. The top navigation bar includes links for Products, Solutions, Academia, Support (which is highlighted in blue), Community, and Events. On the right, there are buttons for 'Get MATLAB', a phone icon, and 'MR'. The main content area has a 'Search Support' bar and a 'Help Center' tab. Below the tabs, there are links for Documentation, Examples, Functions, Videos, and Answers. The 'ga' function page is displayed, with the R2020a version noted. The 'Syntax' section lists various command-line arguments for the 'ga' function. The 'Description' section provides a brief overview: 'x = ga(fun,nvars)' finds a local unconstrained minimum. The page also includes a 'collapse all in page' link and a 'example' link at the bottom.

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CONTENTS

« Documentation Home  
« Global Optimization Toolbox  
« Optimization Problem Setup  
« Choose a Solver  
« Global Optimization Toolbox  
« Genetic Algorithm

**ga**

ON THIS PAGE

Syntax  
Description  
Examples  
Input Arguments  
Output Arguments  
More About  
Tips  
Algorithms  
Compatibility Considerations  
References

Documentation Examples Functions Videos Answers

ga

Find minimum of function using genetic algorithm

R2020a 

**Syntax**

```
x = ga(fun,nvars)
x = ga(fun,nvars,A,b)
x = ga(fun,nvars,A,b,Aeq,beq)
x = ga(fun,nvars,A,b,Aeq,beq,lb,ub)
x = ga(fun,nvars,A,b,Aeq,beq,lb,ub,nonlcon)
x = ga(fun,nvars,A,b,Aeq,beq,lb,ub,nonlcon,options)
x = ga(fun,nvars,A,b,[],[],lb,ub,nonlcon,IntCon)
x = ga(fun,nvars,A,b,[],[],lb,ub,nonlcon,IntCon,options)
x = ga(problem)
[x,fval] = ga(___)
[x,fval,exitflag,output] = ga(___)
[x,fval,exitflag,output,population,scores] = ga(___)
```

**Description**

`x = ga(fun,nvars)` finds a local unconstrained minimum,  $x$ , to the objective function,  $fun$ .  $nvars$  is the dimension (number of design variables) of  $fun$ .

example

# Introduction to Genetic Programming in MATLAB

Let's jump to Module02\_E.mlx

# Introduction to Genetic Programming in MATLAB

- In this lecture, you learned about:
  - “ga” package in MATLAB
  - Implementation of “ga” package in MATLAB
- In the next lecture, we will overview other optimization algorithms available in Python and MATLAB.



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