

Constrained Optimisation

Spoken Tutorial Project

<https://spoken-tutorial.org>

National Mission on Education through ICT

<http://sakshat.ac.in>

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FOSSEE TEAM

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Learning Objectives

In this tutorial, we will learn how to:



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In this tutorial, we will learn how to:

- ▶ Use `fot_fmincon` and `fot_intfmincon` functions in Scilab



Learning Objectives

In this tutorial, we will learn how to:

- ▶ Use `fot_fmincon` and `fot_intfmincon` functions in Scilab
- ▶ Solve Constrained Optimisation problems using `fot_fmincon` and `fot_intfmincon`



System Requirements

To record this tutorial, I am using



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► **Ubuntu 18.04**



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- ▶ Ubuntu 18.04
- ▶ Scilab 6.1.0
- ▶ **FOSSEE Optimization Toolbox
version 0.4.1**



Pre-requisites

To follow this tutorial, you should



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- ▶ **Have basic understanding of Scilab and optimization theory**
- ▶ **If not, for relevant tutorials please visit: <https://spoken-tutorial.org>**



Code Files

- ▶ The files used in this tutorial are provided in the Code files link



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- ▶ Please download and extract the files



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- ▶ Make a copy and then use them while practising



What is the Constrained Optimisation problem?

**A Constrained Optimisation Problem
is a mathematical optimisation model**



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It has:



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It has:

- ▶ **A linear or nonlinear objective function**



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- ▶ **Bounds on decision variables**



What is the Constrained Optimisation problem?

It has:

- ▶ A linear or nonlinear objective function
- ▶ Bounds on decision variables
- ▶ **Linear and Nonlinear constraints on decision variables**



Mathematical Formulation

A general form of a constrained nonlinear optimization problem is:

$$\min_x f(x)$$

subjected to:

$$Ax \leq b,$$

$$A_{eq}x = b_{eq},$$

$$c(x) \leq 0,$$

$$c_{eq}(x) = 0,$$

$$lb \leq x \leq ub,$$

where f , A , b , A_{eq} , b_{eq} , c ,
 c_{eq} , lb , and ub are given.



Example

$$\begin{aligned} \min_x \quad & 0.6224x_1x_3x_4 + 1.7781x_2x_3^2 \\ & + 3.1661x_1^2x_4 + 19.84x_1^2x_3 \end{aligned}$$

subjected to

$$-0.0625x_1 + 0.0193x_3 \leq 0$$

$$-0.0625x_2 + 0.00954x_3 \leq 0$$

$$x_4 \leq 240$$

$$-\pi x_3^2 x_4 - (4/3)\pi x_3^3 + 1296000 \leq 0$$

$$1 \leq x_1, x_2 \leq 99, \quad 10 \leq x_3, x_4 \leq 200$$

$$x_0 = [20, 10, 58.291, 43.69]$$



Integer Constraints

- We will now look at constrained integer nonlinear programming problems



Integer Constraints

- ▶ We will now look at constrained integer nonlinear programming problems
- ▶ These are problems in which some decision variables are constrained to be integers



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subjected to:

$$Ax \leq b,$$

$$A_{eq}x = b_{eq},$$

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$$lb \leq x \leq ub,$$

$$x_i \in \mathbb{Z}, \quad i \subseteq N,$$

where f , A , b , A_{eq} , b_{eq} , c ,

c_{eq} , lb , and ub are given.



Example

$$\begin{aligned} \min_x \quad & 0.6224x_1x_3x_4 + 1.7781x_2x_3^2 \\ & + 3.1661x_1^2x_4 + 19.84x_1^2x_3 \end{aligned}$$

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$$1 \leq x_1, x_2 \leq 99, \quad 10 \leq x_3, x_4 \leq 200$$

$$x_1, x_2 \in \mathbb{Z}$$

$$x_0 = [20, 10, 58.291, 43.69]$$



Summary

In this tutorial, we have learnt how to:

- ▶ Use `fot_fmincon` and `fot_intfmincon` functions of the FOSSEE Optimization Toolbox
- ▶ Solve constrained nonlinear programming examples in Scilab



Assignment

Minimise the following objective function:

$$f(x) = (2\pi x_1 x_2 + 2\pi x_1^2) \times 400;$$

subjected to the given constraints:

$$x_1 + x_2 \leq 12$$

$$200 - \pi x_1^2 x_2 \leq 0$$

$$x_1, x_2 \geq 0$$

$$x_0 = [1, 2]$$



Assignment

The solution to the assignment is

$$f_{\text{opt}} = 75728.822$$

$$x_{\text{opt}} = [3.1692029, 6.3384058]$$



About Spoken Tutorial project

- ▶ Watch the video available at https://spoken-tutorial.org/What_is_a_Spoken_Tutorial
- ▶ It summarises the Spoken Tutorial project
- ▶ If you do not have good bandwidth, you can download and watch it



Spoken Tutorial Workshops

The Spoken Tutorial Project Team

- ▶ Conducts workshops using spoken tutorials
- ▶ Gives certificates to those who pass an online test
- ▶ For more details, please write to contact@spoken-tutorial.org



Answers for THIS Spoken Tutorial

- ▶ Questions in THIS Spoken Tutorial?
- ▶ Visit <https://forums.spoken-tutorial.org/>
- ▶ Choose the minute and second where you have the question
- ▶ Explain your question briefly
- ▶ The Spoken Tutorial project will ensure an answer



FOSSEE Forum

- For any general or technical questions on Scilab, visit the FOSSEE forum and post your question

<https://forums.fossee.in/>



Textbook Companion project

- ▶ The FOSSEE team coordinates the Textbook Companion project
- ▶ We give Certificates and Honorarium to the contributors
- ▶ For more details, please visit:
https://scilab.in/Textbook_Companion_Project



Lab Migration

- ▶ The FOSSEE team coordinates the Lab Migration project
- ▶ For more details, please visit:
[https://scilab.in/
Lab_Migration_Project](https://scilab.in/Lab_Migration_Project)



Acknowledgements

- **Spoken Tutorial and FOSSEE projects are funded by MoE, Government of India.**



Thank you

- ▶ This is Mankrit Singh, a FOSSEE intern 2021, IIT Bombay signing off
- ▶ Thanks for joining

