

# Linear Programming in the Standard Form: Example for Criss-cross and Interior Point algorithm

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<date>

## 1. Introduction

For linear programming or optimization (LP, LO) problems, several algorithms exist, e.g. Simplex method [1]. Two methods and their time complexity will be discussed in detail and an example is given. LP problems can be formulated in standard form and augmented (slack) form.

...

The Simplex method constructs a feasible solution at a vertex of the feasible region (that must be a polytope): It “follows” the path on the edges of the region with non-decreasing values of the objective function until an optimum is reached (see Figure 1)

....

The time complexity of the Simplex algo. is polynomial  $O(2^n)$  [2]. Problem...

...

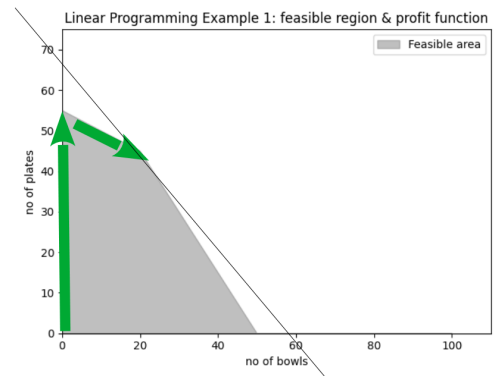


Figure 1: Simplex Algorithm

### Hints:

- You will use THIS template. NO other document templates.
- Topic from teacher until Friday.
- Students can modify the title → ask the teacher
- Copy & paste Internet → F 100% fail
- No teamwork
- Introduction around 1 page or more. Should NOT cover basic topics, e.g. Matrix, Integral, LP
- Math. background should be given to extend that you understand the topic.
- Pictures are YOUR own creation.
- References are important.
- Goal the introduction: understand the topic and problem → mention the solution
- Pictures: Right size, they are not bigger than necessary, not too small. Third of column (33%), see my example
- More than 30% of a chapter is picture → F
- Do NOT forget a caption for code, pictures, formulas, tables (with number)

## 2. Criss-cross and Interior Point algorithm

Criss-cross algorithms are in fact a family of algorithms. The principle is that they “visit all 2D corners of a (perturbed) cube in dimension D [...], in the worst case [3]. Basis is the LP definition as follows

$$Ax = b \text{ (or } \geq, \leq \text{) and } x \geq 0 \text{ (constraints) where } c \in R_n, b \in R_m, \text{ and } A \in R^{m \times n}$$

The formula for the variance  $\sigma^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{N}$  shows the relationship to standard deviation.

....

Step 1: .....

### Hints:

- Describe in detail the approaches, method: Math., steps, easy mini-example
- Does NOT contain ANY Python, C++, Java code.
- Mathematical formulas MUST be created with the formula editor (NO pictures) with font size 10
- Understand the algorithms → advantages ? Solution for the problem (see Introduction), e.g. discuss how the algo. are “better” in terms of Big O (time complexity), pro and cons
- >= 2 pages
- Copy and paste → F

### 3. Example

For the example I chose the following pictures:

1. A purple cat with the ocean background: the reason is that I want to examine the preservation of the color (purple has a high blue ... The cat has a clear shape .... edge, fur ... details. Minimum resolution is HD .... (see Figure 2).

2. ...

...

The following libraries in Python are available:

1. Pulp: .... has a problem with certain assignment problem ...

2. ...



Figure 2: Original lovely cats

Explanation of the code:

1. Firstly, the coefficient matrix A needs to be defined. We use the data from the example pictures (see Figure 2). This is needed for the criss-cross algorithm as an input.

```
A = np.array([[5, 7, 9],
              [14, 10, 12],
              [15, 13, 16]
              ])
b = np.array([1, 1, 1])
```

*Listing 1: Provide a matrix for A*

2. Step 2 of the algorithm...

### Hints:

- This section contains min. 60 % text (not only code), e.g. explanations.
- Do NOT just dump your code here in this document, i.e. if this section contains only code → grade F
- Real-life example, do NOT just use some abstract numbers
- Listings (code) MUST use mono font with size 10
- Understand the data, e.g. for images: resolution, format, original image, type / intensity noise, color space ...
- Give reasons why you chose this data
- For the program example: Clarify what the programmatic alternatives are, e.g. library, implementation from someone else, own implementation. Give a reason why you picked the lib/impl. for this example
- Follow the algorithms from sec. 2: Connect the section 2 algorithm and this example
- NEVER give an explanation like ~~“I found that in the Internet”~~. ~~“I think that it is good.”~~
- Copy and paste → F
- $\geq 3$  pages
- Cross-references: sources, figures, tables etc.
- 

## 4. Summary and Discussion

It could be shown that the Criss-cross algorithm that is a basis-exchange algorithm has an disadvantage compared to interior-point methods that move through the interior of the feasible region, because the time complexity is not polynomial (at least in the case of the Projective algorithm of Karmarkar) ...

### Hints:

- Write a meaningful summary. Argue with hard facts
  - Do NOT write ~~“algorithm A is better or faster than B”~~.
  - Prove with hard facts, e.g. algorithm A has  $O(2^n)$  and B has  $O(\log n)$ . Therefore ...
- NEVER make a statement like ~~“I learned a lot.”~~, ~~“This is very interesting”~~, ~~“It was very difficult”~~, ~~“I like it”~~
- Discussion part should lead the way into further work, examples, theory, e.g.   
“In this report I could not go further into the variants of the interior-point methods. There are promising variants like .... that should be considered ... in practice.” [3]
- $\frac{1}{2}$  -1 page

## 5. References

- [1] Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to Algorithms, Second Edition. MIT Press and McGraw-Hill, 2001. ISBN 0-262-03293-7. Section 29.3, p. 692 ff.
- [2] Klee, V. and Minty, G. How Good Is the Simplex Algorithm? In Inequalities. Academic Press, New York (1972), p. 233

[3] Wikipedia: [https://en.wikipedia.org/wiki/Criss-cross\\_algorithm](https://en.wikipedia.org/wiki/Criss-cross_algorithm)

### Hints:

- A reference is a scientific source (book, paper, published). If source has more than 4 pages, you **MUST also refer to the page**
- NOT a reference
  - source code hosting web pages, e.g. github.com
  - wikipedia.org
  - marketing material, e.g. company “ABC”
  - web page about data science, python
- $\geq 10$  scientific references (digital lib from ACM, IEEE, CS), Google books, publisher, e.g. Springer, Elsevier, ...
- Reference should contain ISBN, ISSN, DOI, or link
- Students have 2 ½ weeks time: Ask questions and follow these requirements!

### General Hints:

- The report is  $\geq 7$  pages
- Scoring: Report: 50%, Midtermin exam: 50%, Presentation: Bonus
- 2 days after submission:
  - On June 5, chat session with questions and answers, e.g. “Why exactly did you use this dataset?”
  - Student will answer via chat immediately.
    - Student answer the question: OK
    - Student cannot answer the question:  
follow-up questions, is student cannot answer → grade F
- You must submit 4 files
  - Submit the PDF and the Office document (Word, OpenOffice or LibreOffice):  
<student-name><number>.pdf and <student-name><number>.doc
  - Submit the code separately = separate file <student-name><number>.py
  - Provide data as zip file <student-name><number>data.zip