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

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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.

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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)

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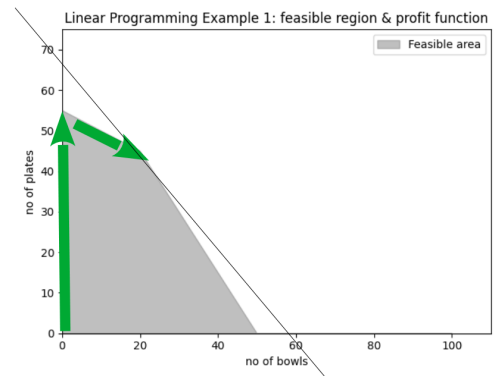The time complexity of the Simplex algo. is polynomial $O(2^n)$ [2]. Problem...

...

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, the 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

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

The formula for the variance $\sigma2 = \frac{\sum_{i-1}^{n}(x_i - \bar{x})^2}{N}$ 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: Orginal 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…

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) …

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

Hints:
- **A reference is a scientific source (book, paper, published). If source has more than 4 pages, you <mark>MUST also refer to the page</mark>**
- **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, pyhton**
- **>= 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 >= 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**