

# FROM LP TO LMI PROGRAMMING USING SCRIPTRUNNER

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**Abstract:** *Scriptrunner is a web application that enables editing and running programs written in various programming languages. Currently supported languages are: C/C++, Java, Fortran, Pascal, PHP, HTML/Javascript, Matlab, Mathematica, Scilab and Octave. The goal of Scriptrunner is writing and publishing of digital books. Each such book becomes "live" because the programs with the preferred, regularly different, input data can be called from it. This article shows how to write a classbook for our students about linear and convex (semidefinite) programming, with many on-line examples. It is well known that most analysis and designs problems in robust and nonlinear control can be formulated as global optimization problems. In the last decade, optimization over LMIs has established itself as a popular convex relaxation technique in the systems and control community. We offer a useful on-line solution.*

**Keywords:** *web publishing, linear and convex programming*

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## 1. INTRODUCTION

The purpose of the Internet is an exchange of the information which is obtained through the creation and the use of dynamical and interactive web pages. The application program Scriptrunner [3] integrates in a simple and easy way such a creation and use in the form of the "living" documents [4] - documents which can contain the text, pictures and multimedia and can also incorporate the execution of the programs written in various programming and scripting languages. Moreover, the reader of such a document has not only option to edit the input parameters of these programs, but can also write and execute his/her own programs without being forced to install the necessary software on his/her computer. The Scriptrunner is an application developed through the academic community and is used as a teaching aid in the various mathematical and computer science courses as well as in the publishing and education. The simplicity of the use makes Scriptrunner an ideal choice for the use in the classrooms as well as for the work at home. Such advantages mentioned above in the text have to be used, especially for education. This work presents how to educate students about linear programming and linear matrix inequalities. These special topics are chosen because they have important role in control theory and optimization, where in fact only very simple linear programming (LP) problems can be solved on the paper. More complicated LP problems and linear matrix inequalities (LMI) can be solved only by computer. From these follows the facts that students have to have appropriate application (that is not for free) for solving these types of problems. By Scriptrunner (and for free) student can learn how to solve these problems and simultaneously solve it, just using internet connection and internet browser. Convex optimization offers great possibility for solving problems on the global level. This type of knowledge demands mathematical and numerical skills

which can be very efficiently developed using Scriptrunner. Code execution is the most used option, because LP and LMIs are solved on this way. In the background of programming code execution lies Matlab with toolboxes and in fact it solves problems of these themes.

## 2. SCRIPTRUNNER

This application [2] is very simple to use and its main idea here is to serve in education. Basic description is given by Figure 1 and Figure 2 where can be seen that on the left side of internet browser is directory tree (directories: **My Files** and **Public Files**) with folders. There are two types of folders: one can hold files with programming code and another holds interactive books (or tutorials, lectures...). Folders are created in the part below directory tree in the browser.

Directory **My Files** holds folders and files made by user and only this user can work with them. If he/she wants to publish his/her work other users will see it. Publishing have to be approved by administrator and then user's work will be copied in directory **Public Files** (Figure 2, right window).

Working environment and other properties of the application can be set in **Settings** shown in Figure 2 (left window).

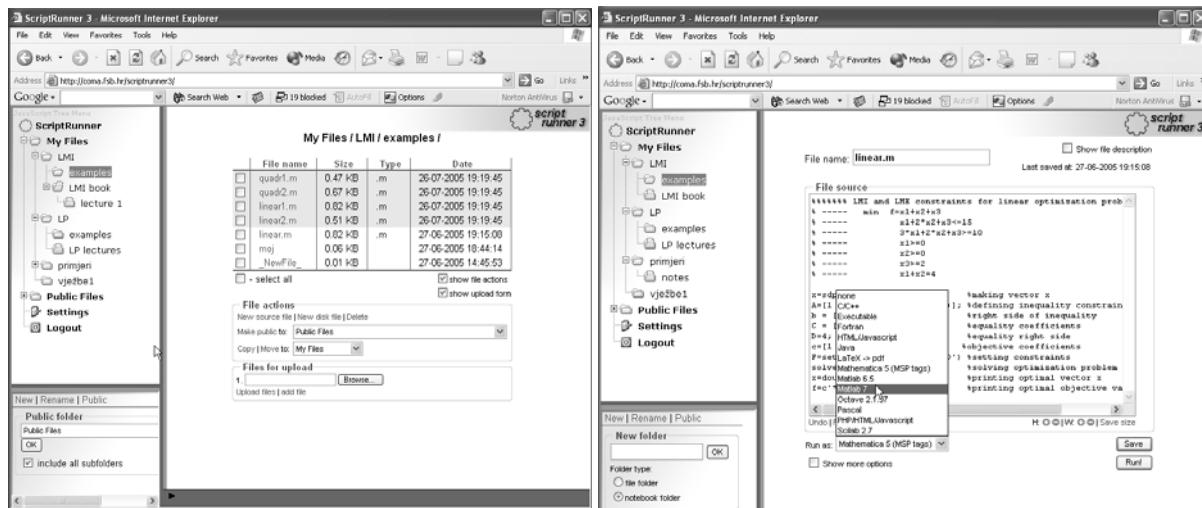


Figure 1: Directory tree with making and running examples

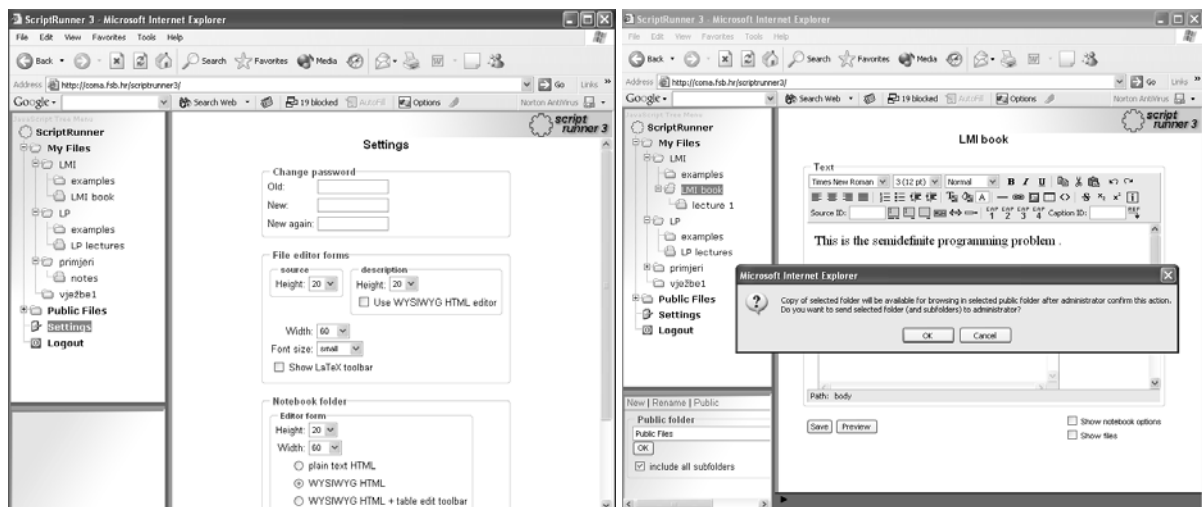


Figure 2: Settings and publishing folders

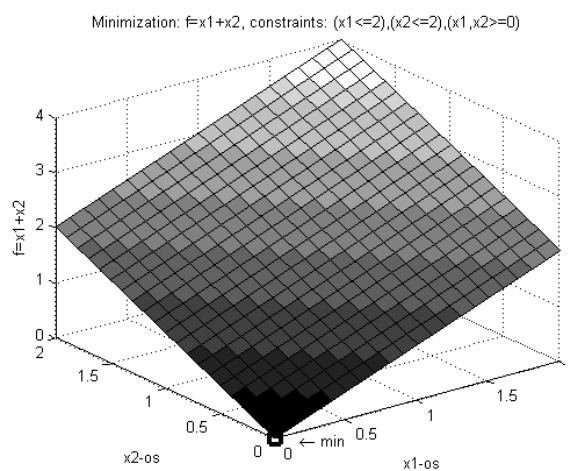
### 3. WRITING INTERACTIVE LECTURES WITH EXAMPLES

#### Example 1.

This example is simple and very useful for understanding LP [1] problem and for finding optimal value, because it gives problem representation in graphical form. This is possible to do just with problems with 2 decision variables.

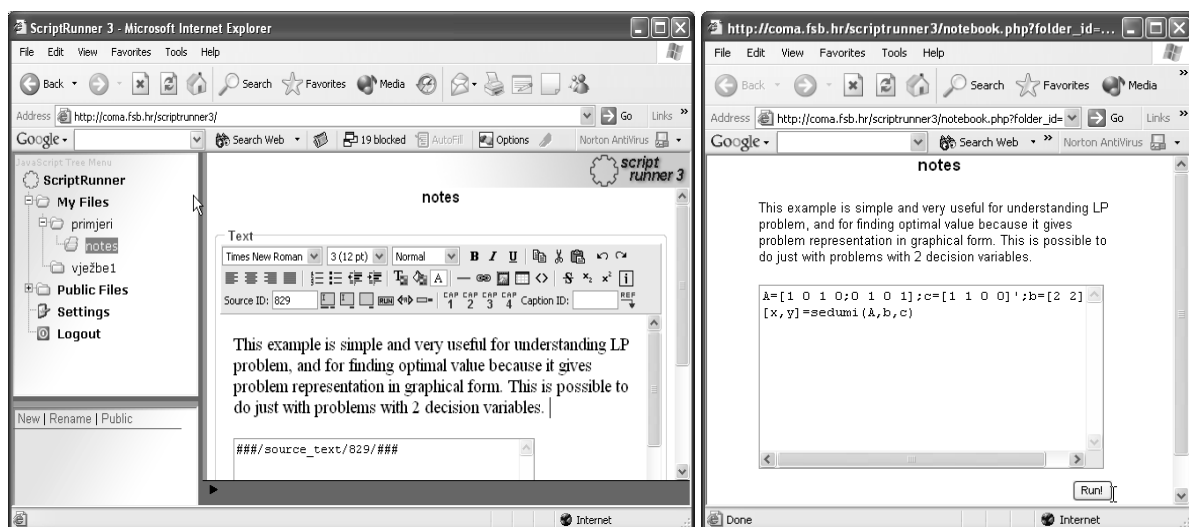
$$\begin{aligned} & \text{minimize} && x_1 + x_2 \\ & \text{subject to} && x_1 \leq 2 \\ & && x_2 \leq 2 \\ & && x_1, x_2 \geq 0 \end{aligned} \tag{1}$$

Graphical representation of this example is shown in Figure 3.



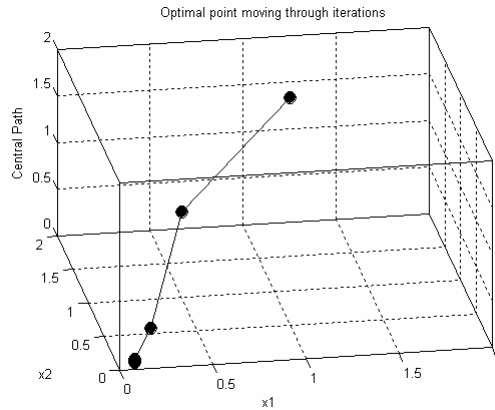
**Figure 3: Graphical representation of feasible and optimal values of 2D LP problem**

This computation is made by Scriptrunner [3] that uses Matlab (toolbox SeDuMi) to execute programming code. Books are written in the interactive environment so that user can change written programming code and execute it to get different result as shown in the Figure 4 (left window shows environment for elaboration of interactive book, and right window shows book for users with "live" programming code).

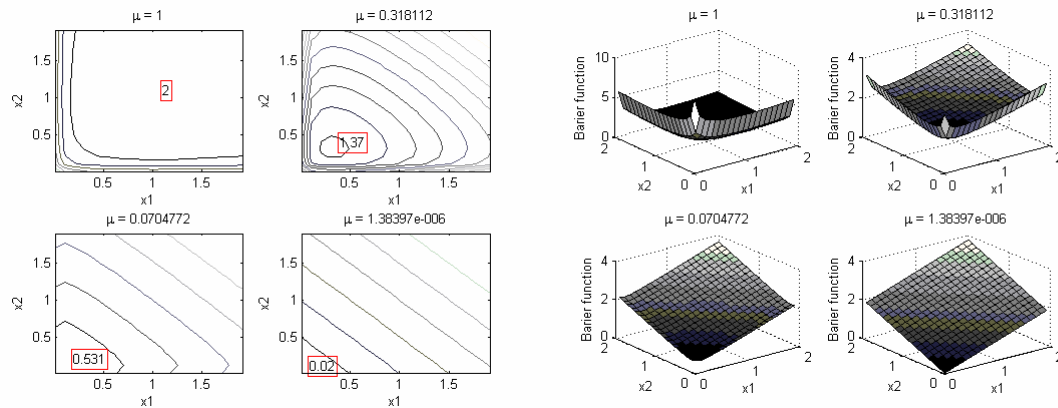


**Figure 4: Making interactive books about LP with Scriptrunner**

Example 1 is solved by interior point method (algorithm called *path-following method* [5]), and graphical results are given by Figure 5 and Figure 6. These results (graphical and numerical) are achieved in the same way as shown in Figure 4, by interactive book in the application *Sciprunner* [3].



**Figure 5: Graphically showed optimal point moving through iterations**



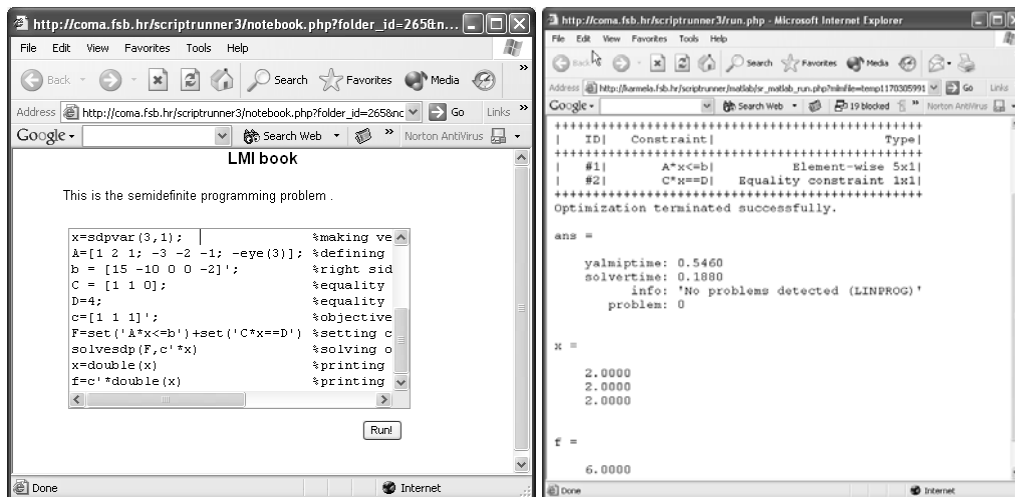
**Figure 6: Graphically showed iterations of finding optimal values for LP problem**

Semidefinite programming (SDP) problems are solved by the same algorithm used in LP, i.e. interior point method. The main advantage of formulating and solving problems as semidefinite is that finding its local optimum is in fact finding its global optimum.

### Example 2.

This example shows how to solve more complicated LP problem (2) using SDP [6]. That means that LP problem is written as LMI and solved as SDP. Figure 7 has two subfigures. Left one gives a look of the interactive digital book with a "live" programming code, and second one shows the solution given by pressing button Run next to the code.

$$\begin{aligned}
 &\text{minimize} && x_1 + x_2 + x_3 \\
 &\text{subject to} && x_1 + 2x_2 + x_3 \leq 15 \\
 &&& 3x_1 + 2x_2 + x_3 \geq 10 \\
 &&& x_1 \geq 0 \\
 &&& x_2 \geq 0 \\
 &&& x_3 \geq 2 \\
 &&& x_1 + x_2 = 4
 \end{aligned} \tag{2}$$



**Figure 7: Making digital book about LMI with "live" programming code**

LMI programming code used in Figure 7 has special syntax that is very familiar with users and is easy to handle but at the other way it solves very complicated and recently unsolvable problems.

#### 4. CONCLUSION

Possibility of writing on-line interactive digital books with Scriptrunner [3] is also useful in interaction teacher-student. As is shown in this work there exist the way of learning topics, in this case LP and LMI. Linear programming has been studied very well, but area of semidefinite programming grows fast and it is popular today in many theories. We have been writing on-line lectures for students about these topics and the main advantage of learning this way are examples. Examples give insight into the real problems and by changing programming code in them student can bring some new conclusions when he/she gets different solutions. When examples are executed given solutions are numerical and graphical nature. This gives better basis for understanding such a type of problems. For iterating processes in background Matlab application with toolboxes is used. Hopefully, we think that this way of learning will make better its quality, and make themes easier to understand.

#### 5. REFERENCES

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