

Comparison of free and commercial software packages for engineering problem solving and education

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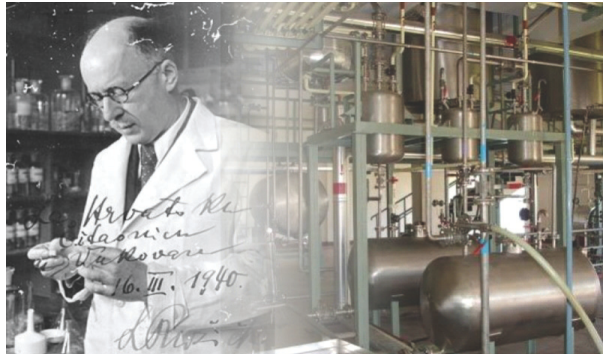


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Comparison of free and comercial software packages for engineering problem solving and education

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Summary

Engineering is application of scientific principles in real life problem solving, or in other words solving practical problems with application of accumulated scientific facts and more or less personal experience. Solving engineering problems often means application of numerical methods for differential equation solving, no matter what engineering branch is in concern. With fast development of personal computers in last two decades of last century, numerical methods moved from mainframe computers in research centers to widely available program packages written for PCs. This transition resulted in development of tools for product design, modeling and simulation which now could be used at universities for education as well as scientific work. *Matlab*[®] is dominant commercial package today, but also there is number of free packages like *Scilab* or *Octave*. This work focuses on comparison of free software packages with commercial reference to determine their fitness to be used as tool for modeling and simulation as well as teaching engineering principles.

Keywords: Matlab, Scilab, Scientific software, simulation

Introduction

Often students and young engineers found themselves overwhelmed with tasks that they need to solve in limited time, and they need tools that can help them to minimize their effort and maximize productivity. Today every engineer and student is forced to use personal computer in order to fulfill their tasks, homework's, calculations and reports. Computer literacy is obligatory today, but mostly it only assumes use of office applications (*MS Office* or *OpenOffice*,...), which is not enough for students in engineering fields of study. First encounter with engineering software most students have at faculties or after graduation at research institutes, and once they learn to use one software package it is very hard to expect that they will move to another one. In Croatia Ministry of Science, Education and Sports had formed referral centers for scientific software to help academic community to acquire and use requested engineering software. Some examples of these centers are center for *MathWorks Matlab*

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(<http://www.matlab.fer.hr/>), *Wolfram's Mathematica* (<http://mrc.systemcom.hr/>) and computer aided engineering CAE (<http://www.cae-refcentar.fsb.hr/>) center. Every software and license obtained from these centers are paid from state budget (Ministry of Science, Education and Sport), in seven years (2002-2009) only CAE center issued 7391 licenses for 50 software packages to 34 institutions which is substantial amount of money.

Current trend in Europe is minimizing state expenses, and some of the biggest European countries (Germany, France, ...) promote moving from proprietary to open source software in all government institutions (from public services, elementary schools to universities) replacing operating systems (*Microsoft Windows* with *Linux*) and applications. Aim of this paper is comparison of commercial, well known software package *Matlab* with open source alternative *Scilab* as tool for scientific calculations, simulations and teaching, and their availability on different platforms. Comparison is focused on features that are useful for teaching engineering subjects.

Matlab (Matrix laboratory) was created in the late 1970's by Cleve Moler who was chairman of computer science department at the University of New Mexico. It was designed with intention to allow students to access *LINPACK* and *EISPACK* libraries without need to learn *Fortran*. Formally MathWorks was founded in 1984 by Cleve Moler, Steve Bangert and Jack Little and *Matlab* as commercial tool was available at the market. *Matlab* is today *de facto* standard and leader in control design engineering and also used in education, in particular teaching of linear algebra, numerical analysis. *Matlab* is used in more than 5000 universities worldwide*, and it is estimated that more than one million people use it for their work.

Scilab was created in 1990 by researchers from French National Institute for Research in Computer science and Control (Institut Nationale de Recherche en Informatique et en Automatique, INRIA) and École nationale des ponts et chaussées (ENPC). In 2003 *Scilab Consortium* was formed to broaden contributions and promote *Scilab* as worldwide reference software in academia and industry, and in 2008. *Scilab Consortium* joined with *Digiteo Foundation*.

Materials and Methods

Software packages used in this paper are *Matlab* 2010a, *Simulink*, MathWorks, trial version, *Scilab*, 5.2.2 and 5.3.0 beta3, Digiteo INRIA. Programs were obtained from Internet (*Matlab*[®] from www.mathworks.com; *Scilab* from www.scilab.org). Both software packages were tested on same PC computer, based on INTEL Dual Core processor (E-5200, 2.5 GHz), 4 GB (DDR2 – 800) RAM under Linux operating system Kubuntu 10.04 64-bit version. Programs

*http://www.mathworks.com/academia/student_version/

were installed following install instructions with default settings. It is important to emphasize that *Matlab* is not free software and *Scilab* is freely (CeCILL license) available as download from Internet for Windows, Mac OSX and Linux in 32-bit and 64-bit versions.

Some simple engineering problems were chosen to be solved by selected software packages as examples, which represent most common problems encountered during engineer study program, namely differential equation solving, integration, modeling, optimization and simulation. To compare speed of *Matlab* 2010a and *Scilab* 5.2.2, test script (Steinhaus, 2008) was used to measure time needed to complete specific tasks.

Results and Discussion

Both Matlab and Scilab are available as installation packages on all major platforms. There are quite few options and types of installation possible, from default installation on single computer to client/server installations (Table 1).

Table 1. Installation options and features

Function	Matlab 2010a	Scilab 5.2.2
Standard OS installation	+	+
Customizable installation	+	+
Silent installation mode	+	+
Client/Server installation	+	+
License management for client/server usage	+	No need - freeware
Online check for updates	+	-

Primary focus of these programs are matrix calculations, they are primary used for numeric calculations in contrast to applications like *Wolfram's Mathematica* and *MapleSoft Maple* which are more symbolically oriented software (Bordeianu *et al.*, 2008). Some of general mathematical features are showed in Table 2.

Most commonly encountered problem in chemical, food or other engineering is solving differential equations or systems of equations because it is mathematical way for expressing change in composition, concentration or dynamics of observed system. It is possible to solve wide range of engineering problems (equations) with built in solvers or with additional toolboxes as shown in Table 2.

Another very commonly encountered problem in engineering is optimization of some kind, process or product optimization which can be solved with numerous optimization algorithms. *Matlab* has two toolboxes that are used for optimization problems (Calberg, 2009): Optimization toolbox and Genetic algorithm and Direct search toolbox. *Scilab* optimization capability's are close to *Matlab's* in sense of available functions and they are either embedded in *Scilab* or available as toolboxes which are mostly just interfaces to optimization

libraries (Baudin et al., 2010). Generalized overview of optimization problem solvers for both packages are given in Table 2.

Table 2. Comparison of available features

Functions	Matlab 2010a	Scilab 5.2.2
Eigenvalues		
Eigenvalues	+	+
Eigenvectors	+	+
Matrix analysis		
Characteristic polynomial	+	+
Determinant	+	+
Hadamard matrix	+	-
Hankel matrix	+	-
Hilbert matrix	+	+
Householder matrix	+	+
Inverse matrix	+	+
Kronecker product	+	+
Pascal matrix	+	-
Toeplitz matrix	+	+
Upper Hessenberg form	+	+
Decompositions		
Cholesky decomposition	+	+
Crout decomposition	+	-
Dulmage-Mendelsohn decomposition	+	-
LU decomposition	+	+
QR decomposition	+	+
Schur form of quadratic matrix	+	+
Smith normal form	\$	-
Singular value decomposition	+	+
Optimization		
Optimization - linear models (Unconstr. / Constr.)	+/+	+/+
Optimization - nonlinear models (Unconstr. / Constr.)	\$/	+/+
Optimization - quadratic models (QP) (Unconstr. / Constr.)	\$/	+/+
Equation solver		
Linear equation solver	+	+
Non-linear equation solver	\$	+
Ordinary Differential Equation solver	+	+
Partial Differential Equation solver	+	*

\$-additional toolbox, separate purchase; *-additional toolbox free

Most of software packages for numerical computation has graphical capability's built in for calculations results representation. *Matlab* and *Scilab* are well equipped with such functionality (Table 3).

Table 3. Graphical functionality

	Matlab 2010a	Scilab 5.2.2
2D Graphics		
Area charts	+	-
Bar charts	+	+
Bubble Plot	+	-
Error bars	+	+
Histograms	+	+
Log Plot	+	+
Log-log Plot	+	+
Pie charts	+	+
Polar Plot	+	+
XY Plot	+	+
3D Graphics		
Charts	+	+
Contour plot	+	+
Height colors	+	+
Spectral plots	+	-
Surface plot	+	+
XYZ plot	+	+

Greatest feature of *Matlab* for teaching mathematical modeling, automation theory and simulation of dynamical systems is *Simulink*. It is a interface to a graphical block diagramming tool and customizable set of block libraries, also it is closely integrated with *Matlab* which provides immediate access to an extensive range of tools for algorithm development, analyzing and visualize simulations, define parameters and test data (Simulink 7.6 product description). *Scilab* has similar tool called *Xcos* (previously *Scicos*), which is installed along with *Scilab*. *Simulink* and *Xcos* are based on large numbers of building blocks (ready to use code) which represents signal sources, mathematical operations, signal operations, matrix calculations and signal sinks for gathering simulation results. All available block are arranged in palettes logically grouped by their function for easier navigation (Fig. 1).

These tools are significantly easier to use because there is no programming required, models are intuitively constructed by dragging and connecting available blocks (Fig. 2). Also, there is possibility to create new blocks form existing ones (superblock feature or mask) or completely new but that requires programming skills (*C*, *Fortran*,...).

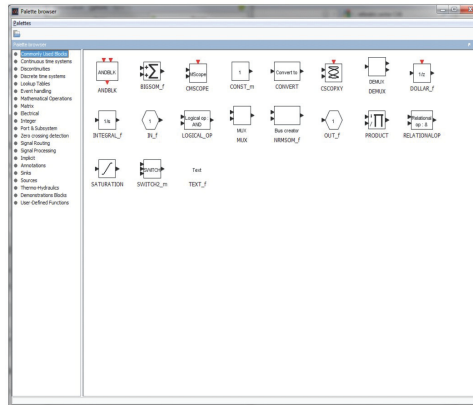


Fig. 1. Block organization in Scilab palette browser

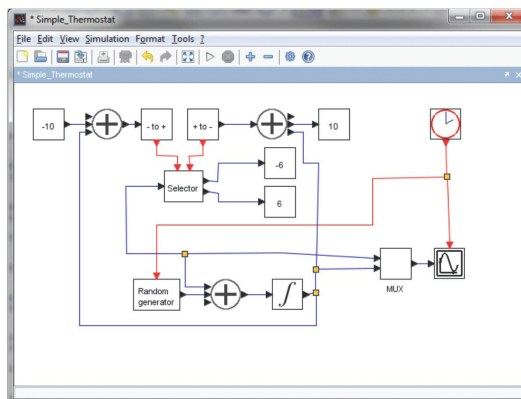


Fig. 2. Xcos model example

Conclusions

Both packages provides to students and researchers with tools which can be easily learned and are easier to use because there is vast number of ready available functions and algorithms and there is no need to program them from scratch in C, C++ or some other language.

Matlab is number one software package for modeling and simulation, but it is commercial software which is expensive. Scilab tends to be a free version *Matlab*, closely representing *Matlab's* syntax, and through every version there are more and more functionality added.

Still *Matlab* has more capability's, but when functionality to price ratio is in concern (in education, private sector), *Scilab* is clear winner because it is freeware published under Cecill licence (2006).

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