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Mathematics can be fun, with FOSS tools

S. Parthasarathy
e mail : drpartha@gmail.com

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1 FOSS for maths

You love maths ? You are curious ? You are a maths guru ? You are a learner, and wish to use maths more effectively ? You all need computer assisted tools for mathematics CATM. We call computer assisted tools for mathematics (CATM), all tools which help in solving mathematical problems. We use the term: CATM, to denote software which does numerical computation as well as software which does symbolic computation. According to wikipedia, the term computer algebra system (CAS) is limited to software which does symbolic computations. Thus, CATM is a superset of CAS.

There is a plethora of CATM available in the market e.g. **Mathematica, Maple, Matlab,** just to name a few. These programs are incredibly powerful, flexible, and usually well documented and supported. Matlab is the one which is fairly common with the engineering/academic community, particularly with those who have to deal with complex mathematical analysis. Matlab is mostly for numerical computation. Mathematica was perhaps the first CATM to give you symbolic computing capability. You can get a textual formula as answers to your questions, instead of a numerical value. Maple is another popular CATM which gives the power of numerical analysis as well as that of symbolic computation.

Each of these CATM has its own strengths and weaknesses. The common factor, of course, is that they are all commercial products, and so they cost money. Unfortunately, they cost a lot of money. This can be a major let-down, to many of us. There do exist student versions of these CATM, but these are usually crippled, with many irritating limitations and restrictions. To add to these woes, there is also the lurking fear of cost of updates and enhancements. Moreover, as a closed community, producers as well as users of such CATM cannot benefit from the contributions of a community of dedicated and competent users. Fortunately, there is a way out FOSS based CATM.

As is usual in the FOSS world, there is a whole zoo of CATM. It would be impossible to highlight all these in a short article like the present one. This article focuses on just a few FOSS-CATM :

- Sage
- Scilab

- GNU/Octave
- Maxima
- R
- PSPP
- KNIME
- Geogebra
- LaTeX (dtp tool)

The above CATM are listed in this article, in no particular order. For each of these CATM, the URL which you can use as a starting point, is also given below. All these CATM have advantages and drawbacks, and none of them can be considered perfect or infallible. The common feature of all these CATM, is that they are all very mature products, and are used for serious applications (even, Ph. D theses). They are all, rather general purpose softwares, not specific a single domain (e.g. heat transfer problems). Since they cost next-to-nothing, you can download all, and try them out on problems of your choice, and choose the one which is most appealing to you. You can always hunt on the w-w-web, if you need anything specific to your requirements.

In keeping with FOSS traditions, this article will describe only Linux based versions (MS worshippers, please excuse). Wherever possible, comparisons are made with commercial CATM, although it is not a good idea to compare apples with oranges.

2 FOSS-CATM student's treasure, teacher's pride

In an (eternally) developing country like India, it would be unreasonable for teachers (like the current author) to expect students (and teachers) to possess their own, legal copies of commercial CATM. A whole world of exciting discoveries and experiences is denied to the students (and teachers), because of this limitation. Even, practising engineers find it difficult to resolve certain problems, due to the complexity of the problem, and due to the absence of appropriate CATM in their parent organisations. They either shun mathematics altogether, or use less accurate analysis tools. All this can change, by the adoption of FOSS based

CATM. When a student solves a mathematical problem by hand, he needs to check out and make sure he is correct. His teacher may not always be around to correct him. FOSS based CATM can be an excellent way out.

Imagine the tremendous advantage a student can get when he uses such tools, in addition to the usual classroom-based, blackboard based teaching. These tools also offer immense possibilities for cooking up your own mini-projects.

2.1 Sage

Sage (http://www.sagemath.org/) is a popular CATM. The main features of Sage are :

- Free,viable alternative to expensive maths tools (Magma, Maple, Mathematica and Matlab)
- Combines the power of many existing opensource packages into a common Python-based interface.
- community support
- Profusely documented
- Regularly updated

The down side of Sage : Sage is HUGE ! Sage is a distribution of over 90 FOSS packages for symbolic, numerical, and scientific computation. So, if you want to exploit it to the fullest, be ready to put in lots of work ! And, also be ready to learn Python programming.

2.2 Scilab

Scilab (a FOSS CATM) is perhaps the best clone of Matlab (commercial software).

Scilab (http://www.scilab.org/) comes from a famous research institution in France : INRIA (Institut National de Recherche en Informatique et Automatique). Its origin can be traced back to the Blaise Project, which started in 1980. In all these years, Scilab has grown to be a very sophisticated, mature, and rich CATM. It has been used successfully in countless number of application areas.

Scilab is continuously updated and maintained. Your matlab *.m files will work under Scilab, thanks to a translation command (m2sci) of Scilab (there are some minor problems though). Although Scilab is primarily a tool for numerical mathematics, there are extensions possible to aid its use in symbolic mathematics. Scilab has interfaces to maple and mupad for symbolic mathematics (compare with similar feature of matlab). Scicos, which is a block diagram modeler and simulator, comes bundled for free, with Scilab. Scicos may be compared to Simulink of Matlab. Scicos makes analysis of many engineering systems, feel like a breeze. Scilab is an interpretor. You can enter your Scilab commands one-by-one and see them being executed. You can also collect a whole set of commands, and logic, together in a script file. And execute the script, which will then execute the whole program for you. Such scripts also offer the advantage that you can exchange them with your friends and colleagues. By using the I/O redirection features of Linux/Unix, you can create an interesting orchestra of programs.

2.2.1 Documentation and support

Scilab is surprisingly very well documented (in English). There are well-written textbooks (in English) available. The quantity and quality of English language documentation available, deflates the myth that the French do not like using English. There is of course a very large amount of community support, in the form of mailing lists, Usenet groups, and web-sites. There is a very good community of Scilab users in India. So, your Scilab guru is just an email away.

2.2.2 Visualisation

A remarkably rich range of plotting and visualisation functions come with Scilab for free. These will make your mathematics much more appealing and expressive. You can make sophisticated 2 D plots, or a wide range of 3 D plots.
In 2 D plots, you can have classical f(x) type of plots, or you can have histograms, or contour plots, or field plots (and more). In 3 D plots, you can make solids, or can have meshed plots .
You can superimpose one plot over the other. You can of course play with colors, and even rotate the plots. It is also possible to add animation to the graphics generated. Scilab allows you to export the graphics such that you can include them in LaTeX files, for publication.

2.2.3 Toolboxes

Scilab comes with a rich collection of toolboxes. A toolbox is a collection of functions, specific to a certain area of interest. For instance, metanet is a toolbox for solving graph-theoretic problems. Scicos is a toolbox for creating blockdiagrams of dynamic systems, and anlysing them. You have toolboxes for image processing, digital signal processing, fuzzy logic etc. etc. The list is very very long. In addition, you can download and add toolboxes generated by the Scilab community of users. You can also write your own toolbx and donate to the community. You can interface your own, specially created external programs, with Scilab. So, the possibilities are almost endless.

2.2.4 Scicos

Scicos (http://www.scicos.org/) is a toolbox which comes bundled with Scilab. With Scicos you can assemble block diagrams, to model and simulate the dynamics of hybrid dynamical systems and compile your models into executable code. Ready-made palettes exist, which contain blocks for various physyical subsystems and components. Scicos itself is based on a more versatile modeling language called Modelica. Scicos is used for signal processing, systems control, queuing systems, and to study physical and biological systems. New extensions allow generation of component based modeling of electrical and hydraulic circuits using the Modelica language. You can generate C code from a Scicos model, using a Code Generator (compare with real time workshop of Matlab). You can generate hard real-time control executables with Scicos-RTAI and Scicos-FLEX

2.3 GNU Octave

GNU Octave (http://www.gnu.org/software/octave/about.html) was originally conceived (in about 1988) to be companion software for an undergraduate-level textbook on chemical reactor design being written by James B. Rawlings of the University of Wisconsin-Madison and John G. Ekerdt of the University of Texas. This effort later transformed Octave into a more flexible and versatile tool. GNU Octave is a high-level language, primarily intended for numerical computations. It provides a convenient command line interface for solving linear and nonlinear problems numerically, and for performing other numerical experiments using a language that is mostly compatible with Matlab. It may also be used as a batch-oriented language. GNU Octave is distributed with many popular Linux distributions. Look around, your own distro has probably GNU Octave built in. Or, you can always download a copy from the web.

2.4 Maxima

Maxima (http://maxima.sourceforge.net/index.shtml) is a descendant of Macsyma, the legendary computer algebra system developed in the late 1960s at the Massachusetts Institute of Technology. It is the only system based on that effort still publicly available and with an active user community, thanks to its open source nature. Macsyma was revolutionary in its day, and many later systems, such as Maple and Mathematica, were inspired by it. Macsyma was maintained by William Schelter from 1982 until he passed away in 2001. In 1998 he obtained permission to release the source code under the GNU General Public License (GPL). Macsyma was renamed as Maxima, and made available to the FOSS world. Maxima is a system for the manipulation of symbolic and numerical expressions, including differentiation, integration, Taylor series, Laplace transforms, ordinary differential equations, systems of linear equations, polynomials, and sets, lists, vectors, matrices, and tensors. Maxima yields high precision numeric results by using exact fractions, arbitrary precision integers, and arbitrarily precision floating point numbers. Maxima can plot functions and data in two and three dimensions.

2.5 R

This enigmatically named tool is a boon for people who indulge in statistics and probability related computing. R (http://www.r-project.org/about.html) is a free software environment for statistical computing and graphics. R can be downloaded from any one of the CRAN (http://cran.r-project.org) mirrors , two of which, are located in india. R compares with other statistics packages like SPSS.

2.5.1 R front end

R Commander (http://socserv.mcmaster.ca/jfox/Misc/Rcmdr/) is a GUI front-end for R.

2.6 PSPP

PSPP (http://www.gnu.org/software/pspp/) is a program for statistical analysis of sampled data. It is a Free replacement for the proprietary program SPSS, and appears very similar to it with a few exceptions.

The most important of these exceptions are, that there are no time bombs; your copy of PSPP will not expire or deliberately stop working in the future. Neither

are there any artificial limits on the number of cases or variables which you can use. There are no additional packages to purchase in order to get advanced functions; all functionality that PSPP currently supports is in the core package.

PSPP can perform descriptive statistics, T-tests, linear regression and non-parametric tests. Its backend is designed to perform its analyses as fast as possible, regardless of the size of the input data. You can use PSPP with its graphical interface or the more traditional syntax commands.

For more details on PSPP, please visit the PSPP home page mentioned above.

2.7 Geogebra

Geogebra (https://linux.softpedia.com/get/Education/GeoGebra-18958.shtml) is an open source, freely distributed and cross-platform graphical software that is capable of uniting geometry, calculus and algebra into a single and handy program that you can use anywhere and everywhere.

2.8 LaTeX

Although strictly it is not a CATM, LaTeX offers an extremly rich combination of tools to make creation of mathematically rich text. A showcase of LaTeX capabilities is available at :: `http://drpartha.org.in/publications/torture2.pdf`, a detailed ebook is available at `http://drpartha.org.in/publications/LFMbig.zip`

3 Concluding remarks

We have seen, only a few of the many FOSS tools available for doing maths. There are literally hundreds of software available for making your maths easier. Your choice will depend on your specific needs, and on how comfortable you feel with each of these software.

Here are some sources where you can look for maths software (some of them may not be FOSS):

- CAS. Primarily symbolic maths ::
  http://en.wikipedia.org/wiki/Comparison_of_computer_algebra_systems
- Symbolic and numeric maths. Mixed list.::
  http://directory.google.com/Top/Science/Math/Algebra/Software/

- Numeric maths ::
  http://en.wikipedia.org/wiki/List_of_numerical_analysis_software
- Graphing and ploting::
  http://en.wikipedia.org/wiki/List_of_graphing_software
- Statistics software::
  http://en.wikipedia.org/wiki/List_of_statistical_packages

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The reader will be convinced that there is no more excuse for not taking maths seriously.

The author invites suggestions, queries and remarks from readers of this article. The author invites particularly members of the academic community (both teachers and students) to react.

4 About the author

Fig. 1: The pensive Professor

Parthasarathy is an aggressive supporter of FOSS. He teaches discrete mathematics, and preaches LaTeX and Linux, to undergaduate students of Computer Science, at Hyderabad, India. As a formally qualified control engineer, he uses Scilab regularly. He also gives demos / lectures (lectdem) on Scilab, FOSS, LaTeX , regularly. He would be happy to assist anyone, particularly students, teachers, and institutions, who are genuinely interested in these topics.

His contact address is : drpartha@gmail.com

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