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Online manual on numerical computation

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Abstract

We present a tutorial on numerical computation for undergrads in Sciences, Maths and Engineering, based on Octave, a popular framework for numerical analysis which, in addition, is FOSS (Free & Open Source Software). So it can be freely run on several operating systems: Windows, MacOS, any GNU-Linux flavour, FreeBSD and, even, on Android mobile platform. The tutorial is given as a static web page with almost no extra complexities, such as database engine, dynamic rendering via PHP or similar. All the workflow is arranged through FOSS with full respect to standards.

Keywords: FOSS; octave; webpage; tutorial; markup language; markdown

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1. Introduction and Aim

We introduce a web tutorial on numerical computing based on Octave, a popular software package for numerical analysis which, moreover, is FOSS (Konstantinov, 2007) and, therefore, can be installed and executed on several computer environments: Windows, MacOS, any GNU-Linux distribution or even the mobile platform Android. Since it is FOSS, all relevant standards are rigorously fulfilled and no patents have to be honored.

The target audience for the tutorial are students in Science (Physics, Chemistry...) Mathematics and Engineering (STEM areas) and teachers of those subjects which want to be introduced into these tools.

Octave consists of the following three elements:

- An interpreted programming language.
- A command-line interface (CLI) based on the language which, moreover, works as a pocket calculator.
- A graphical user interface (GUI).

The aims of the tutorial are the following:

- Introducing students and teachers to the basics of the Octave programming language.
- Introduction to the usage of CLI and GUI tools.
- Application of the obtained skills to the corresponding subjects.

We can also define a series of meta-objectives related to the spirit of the proposal and the creation of the tutorial itself:

- To provide a replacement for equivalent propietary tools (Deliyannis, 2012)
- Introduction of FOSS and its philosophy within the educational environment.
- Provide a new life for old educational webpages.

2. Methodology

The tutorial is presented as a very simple static webpage, based on the modern specification of HTML5 (https://www.w3.org/html/wg/), and with nearly no extra complexity -such as a database engine or dynamical content generator via PHP or similar. Only a CSS (cascade style sheet) and some JavaScript is applied for the mathematical expressions (https://www.mathjax.org/). Despite the simplicity of the tools, the result is esthetically attractive and provides support for graphics and multimedia elements.

The tutorial is organized on the static web generator Jekyll (also FOSS), which allows the use of a simple markup language, such as Markdown (Gruber, 2012). The advantages of this workflow are the following:

- Mathematical expressions can be used directly in LaTeX (https://www.latex-project.org/), through MathJax.

- Syntax highlighting. The parts of the tutorial which contain Octave code are highlighted through colors distinguising the different elements.
- Responsiveness to device geometry: changes on the screen size lead to an appropriate redistribution of the elements, even on mobile devices.
- Easy to maintain: Markdown files are easier to edit, correct, translate, etc. by a didactic team than the corresponding HTML files.
- Easy to host: since the final product are plain HTML documents, with no associated database and no engine for dynamical content, it is easier to host on a webserver.
- Patent-free: the whole creation process of the tutorial is based on FOSS applications which are patent-free.

Teacher autonomy: the technical skills required in order to write and maintain such as tutorial are not very demanding. This allows the teacher to control the edition process of his/her own material immediately.

3. Main results

Let us discuss the different elements characterizing the tutorial:

3.1. Jekyll

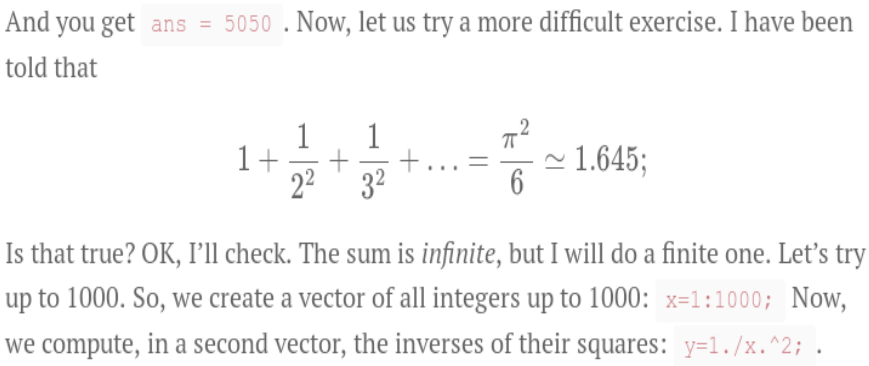
This is the content generation engine which, starting with Markdown plain-text files, dumps the result into HTML assuming certain style sheets, file structure, internal links, etc.

Jekyll is based on Ruby, a high-level programming language. Nonetheless, no knowledge of Ruby is required in order to install and run Jekyll on a personal computer or laptop.

3.2. Mathematical expressions

Mathematical formulas can be written directly in LaTeX format on the Markdown document. The LaTeX code is copied into the HTML document and later processed by the browser through a JavaScript application called MathJax (https://www.mathjax.org/).

There is no need to prepare the mathematical expressions as separate graphics files, as it was customary (see Fig. 1).


And you get `ans = 5050`. Now, let us try a more difficult exercise. I have been told that

$$1+\frac{1}{2^2}+\frac{1}{3^2}+\ldots=\frac{\pi^2}{6}\simeq 1.645;$$

Is that true? OK, I'll check. The sum is *infinite*, but I will do a finite one. Let's try up to 1000. So, we create a vector of all integers up to 1000: `x=1:1000;` Now, we compute, in a second vector, the inverses of their squares: `y=1./x.^2;`.

Figure 1. Rendering of mathematics

3.3. Syntax Highlighting

Since we are considering a programming language (https://gnu.org/software/octave/), it is pedagogically convenient to separate the code chunks from the explanations and, moreover, highlight its different elements, usually with colors and typographical effects.

All this is internally carried out by the Jekyll processor. The teacher only has to label correctly the parts including code (see Fig. 2).

A last little piece of code, to show how beautiful mathematical plots can get:

```
> t = 0.0:0.005:50;
> alpha = 1.0;
> h = plot (cos(t),sin(cos(t/alpha).*cos(t)));
> axis([-1,1,-1,1],"manual")
> for i=0:200
>     alpha=1+i/800.;
>     y=sin(cos(t/alpha).*cos(t));
>     set(h,"YData",y);
>     pause(0.1);
> endfor
```

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>    y=sin(cos(t/alpha).*cos(t));
>    set(h,"YData",y);
>    pause(0.1);
> endfor
```

Figure 2. Code snippet with syntax highlighting (up;) the same code without highlighting (down), edited rightly in HTML.

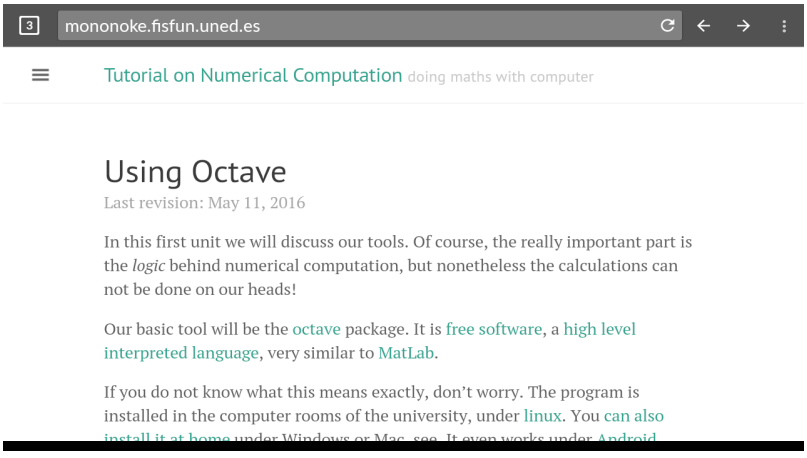

Figure 3. Desktop view.

3.4. Adaptability to all types of devices

HTML5 specifications allow to define in the style-sheet (CSS) how the content is adapted to different screen sizes. Within the Jekyll engine we have several "themes" or visualization styles, most of them programmed for all kinds of devices. For this project we have chosen a clear and light theme, without JavaScript (https://www.mathjax.org/). See Figs. 3, 4 and 5.

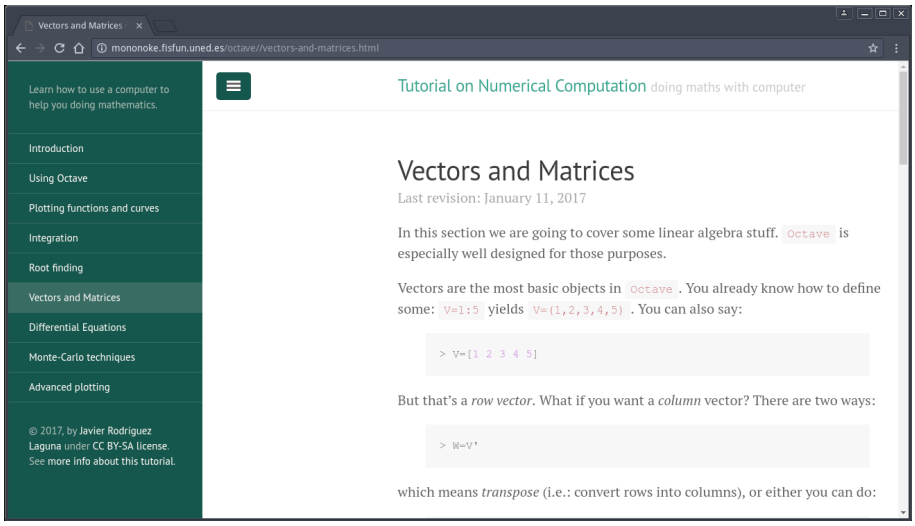

Figure 4. Tablet view.

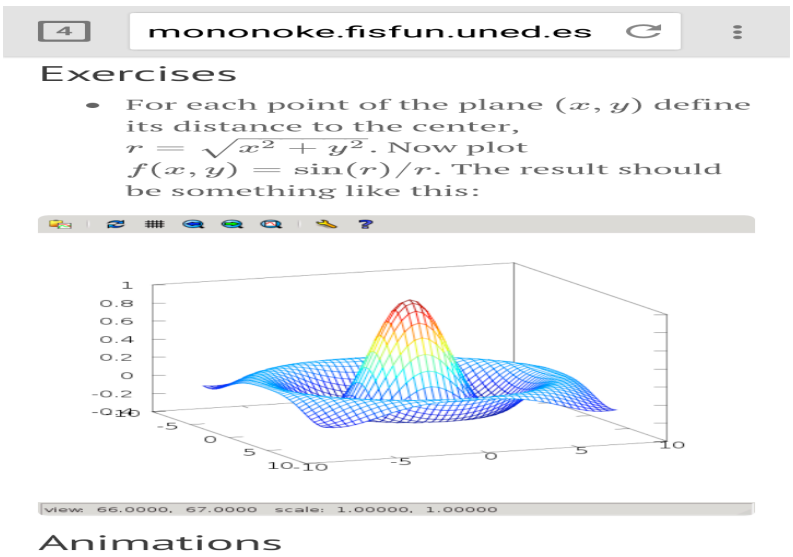

Figure 5. Mobile view.

3.5. Markdown

The key to the simplicity of the project resides in the fact that the teacher does not have to learn a complicated language such as HTML, and instead he/she must write in plain text in a very natural way, including simple marks to format the text. For example, in Markdown paragraphs are signaled leaving a blank linke between them; in order to emphasize text, it is enclosed between asterisks (*like this, for example*); headlines are introduced with the hashtag symbol "#", as many of them as the required nesting depth.

In summary, Markdown possesses a very gentle learning curve and allows for easy maintenance of the original material.

4. Conclusions

A tutorial on numerical calculations is presented in the form of a webpage that is both simple but appealing, and with a modern look and feel, adapted to mobile devices. The whole project has been carried out with FOSS tools, which allows for the following advantages:

- It is a patent-free project and, therefore, affordable in all socioeconomic development contexts.
- It is based on public protocols and widely employed standards.
- It can be developed and maintained by anybody assuming minimal technical skills.
- It allows to revitalize educational webpages which have been rendered obsolete.

Therefore, we believe that our project traces a path for the empowerment of the teacher in the context of the challenges presented by the new technologies, allowing for their autonomy in the generation of online contents.

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