

RECENT ACADEMIC ACHIEVEMENTS OF E-FOTO GNU/GPL EDUCATIONAL DIGITAL PHOTOGRAMMETRIC WORKSTATION

G. L. A. Mota*, J. L. N. e S. Brito, N. dos Santos, O. Bernardo Filho, J. A. Ribeiro, R. L. R. Borba

Post-Graduation Program in Geomatics, Rio de Janeiro State University, Rio de Janeiro, Brazil
(guimota@eng., jnunes@, neide@ime., orlando@eng., jaraujo@uerj.br, rogerioluisribeiro@yahoo.com)

Commission VI, WG VI/1, VI/2

KEY WORDS: Digital photogrammetry, Education, Digital Photogrammetric Workstation, Free Software, Educational Commons

ABSTRACT:

The privacy of source code makes, in many situations, commercial application software unable to academic purposes. Such applicative programs are like “black-boxes”, allowing only data input and results output, as a function of the graphical user interface manipulation. It strongly hinders their application to education, since users remains alienated of what exactly is performed in the applicative background. A common proposal for overcoming such limitations is the development and usage of free software. The academic community of distinct knowledge areas is, indeed, being benefited by free software development for educational and research purposes. However, Digital Photogrammetry is a field that remains practically unexplored. One exception is the E-FOTO project, which develops the only GNU/GPL environment for research, teaching and learning of Digital Photogrammetry that encompasses an Educational Digital Photogrammetric Workstation (EDPW). E-FOTO project aims at producing and sharing without limitations with the academic community software and documents. This paper is devoted to the pedagogical design of E-FOTO Educational Digital Photogrammetric Workstation, besides the project main achievements and repercussions. Along this paper, it is shown what tasks of the photogrammetric process should be covered by the EDPW, the free electronic version of the only digital photogrammetry book edited in Brazil, the software tutorials and the self-learning conception of E-FOTO. Finally, the future expectations for this project are enumerated.

1. INTRODUCTION

Recent corporative scenarios have been imposing changes to the professional profile, demanding people able both to learn in non-conventional ways and to work collaboratively to engender innovative solutions. As a consequence, the technical-based education must rethink about the established focus in order to improve skills and competencies in students, such as learning to learn and to learn with autonomy in a scientific and technological environment (Longo, 1996).

In engineering education, these challenges can be addressed with an integrated approach putting together teaching, learning and research, where the computer plays a significant role. It allows students, for example, to develop and test alternative assumptions, implementing their designs and models, to build a variety of representations for the studied phenomena, by using different kinds of language and levels of abstraction. Besides, in a digital environment, it is possible to simulate events in different scales and values, slower or faster than in nature, overcoming costs, complexity and danger.

Another interesting possibility due to computers and the Internet is collaboration; by such means students can work together and share their assumptions, ways of solving problems and results.

In the specific case of the cartographic engineering education, Digital Photogrammetry's teaching and learning process (Coelho Filho and Brito, 2007) is a critical component, where computers play a key role. That has motivated E-FOTO project, whose major objectives address researching, developing and

implementing a framework for teaching, self-learning and research of Digital Photogrammetry.

The current paper is devoted to the presentation and discussion of the technical and pedagogical aspects of the E-FOTO project. To achieve that purpose, section 2, briefly, presents the basis of Digital Photogrammetry teaching and learning process. Section 3 offers a comprehensive overview of the project, focusing on its educational aspects. Section 4 exposes our conclusions and the future works related to E-FOTO educational tools development.

2. DIGITAL PHOTOGRAMMETRY EDUCATION FUNDAMENTALS IN ACADEMIC ENVIRONMENT

Photogrammetry is a set of technical procedures for processing photographic imagery (2D image-space) aiming the mathematical modeling and reconstruction of a 3D scenario (the terrain or the object-space). The state of the art of photogrammetry is what is so-called “Digital Photogrammetry”, which uses either digital or digitalized-frame imagery and computational processes besides algorithms for scene reconstruction.

The utility of digital photogrammetry goes from the virtual reality to Medical applications. One could mention, for instance, the volumetric quantification of lung cancer nodules, from a set of images taken by a helicoidal tomograph (Mota and Brito, 2005). The non-invasive surveying of archaeological sites and the record of historical monuments and buildings are also possibilities of application of photogrammetric techniques (Kraus, 2000). Topographic mapping generally employs digital

photogrammetry for imaging earth surface and for its 3D mapping.

The set of hardware and software components able to perform the photogrammetric tasks is what is meant by a “Digital Photogrammetric Workstation (DPW)” (Brito and Coelho Filho, 2005). Indeed, DPW’s are solutions of photogrammetric software that came out in the early 1990’s to substitute the opto-mechanical stereo plotters (Phem and Grabmaier, 2004). Besides, the development of electronics and computer science has been opened new opportunities in the areas of hardware, methodology and integration.

Many factors have contributed to the fast development of digital photogrammetry. (Dowman *et al.* 1991) pointed out: (1) the increasing availability of digital imagery, especially from (high-resolution) satellite born sensors; (2) the availability of computers and workstations with high-capacity CPU and with many innovative and reliable photogrammetric accessories; (3) the data integration in one single computational system such as the Geographic Information Systems (GIS); (4) the real-time applications, and; (5) the CAD software and the industrial applications.

One obstacle to the insertion of the state of the art photogrammetric hardware and software in educational environments is the unaffordable prices of photogrammetric software licenses. This reality imposes many restrictions to the integration of theory and practice in educational programs, thus, leading to weakness in the curricula of cartographic and surveying engineering courses.

Due to the intensive use of digital computers in the context of cartographic mapping production, two skills need to be developed: on one hand, the algorithms and the mathematics embedded on the photogrammetric procedures needed to be clearly understood. The same reasoning applies to the quality control of results and products derived from the photogrammetric mapping. On the other hand, it is necessary to understand the concepts behind the workflow of the photogrammetric mapping process implemented in a DPW.

Professionals with no practical experience are certainly one of the consequences of the development only of the first skill above mentioned. In addition, the lack of knowledge about the algorithms applied in each step of the photogrammetric workflow forms professionals without critical sense and with difficulties of adaptation to the technological development. The black-box architecture of commercial DPW solutions is responsible for this limitation (Brito *et al.*, 2006).

According to (Coelho Filho and Brito, 2007), the core of topics related to digital photogrammetry comprises the following: (1) introduction to photogrammetry; (2) basic principles of photogrammetry; (3) digital image processing applied to photogrammetry; (4) inner orientation of digital imagery; (5) exterior orientation of digital imagery; (6) analytical phototriangulation; (7) image rectification and normalization; (8) digital surface model extraction; (9) orthorectification, and; (10) photogrammetric mapping stereo-plotting. Table 1 shows a comparison between the syllabi of a reviewing course and three Master Courses in digital photogrammetry with the Modules of the Educational Digital Photogrammetric Workstation (EDPW) developed by the E-FOTO project.

<u>Topics</u>	<u>Digital Photogrammetry Courses</u>				<u>EDPW</u>
	(1)	(2)	(3)	(4)	
Introduction	X	X	X	X	
Image Acquisition	X		X	X	
Image Rectification			X		X
Inner Orientation	X	X	X	X	X
Exterior Orientation	X	X	X	X	X
Phototriangulation	X	X			X
Digital Image Processing and Template Matching	X			X	
Image Normalization (Epipolar Resampling)	X		X	X	X
Digital Surface Model Extraction	X	X	X	X	X
Ortho-rectification	X	X	X	X	X
Photogrammetric Mapping Stereo-plotting		X		X	X
Close-Range Photogrammetry	X				
(1) Master Degree in Geographic Engineering - The Coimbra University, Portugal (2) Reviewing in Digital Photogrammetry. ITC, The Netherlands (3) Master Degree in Geomatics – Uerj, Brazil (4) Post-Graduation Program in Cartographic Sciences – Unesp, Brazil					

Table 1. Comparison of the syllabi of four courses in digital photogrammetry with the modules of the EDPW Implemented in the E-FOTO Project

One could observe in Table 1 that most of the parts of the core subjects in digital photogrammetry syllabi are covered by the EDPW implementation. Therefore, E-FOTO's educational environment permits students to analyze the didactic contents of the photogrammetric topics, to manipulate and to establish relationships between variables and the performance of the algorithms, and to become familiar to the mathematical principles behind the implemented solutions (the white-box approach). The study of the orthorectification, for instance, aims at transforming central-perspective images onto orthoimages. According to E-FOTO's pedagogical philosophy, there is no sense in introducing both the central perspective and the orthogonal one without explaining the mathematical principles and algorithms underlying the orthorectification process.

3. THE E-FOTO PROJECT

Digital photogrammetry has been employed in large scale since 1995. In under development countries, its popularisation came later. For instance, in Brazil, according to (Brito and Coelho Filho, 2005) its utilization started in 1998. The state of the art of digital photogrammetry involves the usage of DPW. Although a DPW encompasses a dedicated hardware and software, this term will hereafter refer to software.

As previously mentioned, the commercial value of a proprietary DPW licence – in the order of thousands of dollars – hinders its use for educational purposes. Nonetheless, even institutions in economic conditions to effort the licence cost can conclude that their exploitation for educational purposes is limited. First, it is due to the fact that the employed algorithms are kept as business secret. Moreover, in most cases, it is not possible to include user-developed solutions and algorithms. Indeed, like any proprietary system, commercial DPWs are black-boxes. Thus, their usage for didactic and research purposes is, in fact, very limited.

The E-FOTO project tries to overcome these difficulties by the development of an EDPW based on the free software community principles. Since it is an open source project, the "black-box" can be opened, examined and modified for those with the will and the skill to investigate (Nichols and Twidale, 2003). Such aspects bring considerable advantages: any one can freely use it, study its source code, develop additional algorithms and redistribute it.

The EDPW comes alongside with several E-FOTO's products: (1) an e-book of digital photogrammetry; (2) the only digital photogrammetry book edited in Brazil; (3) the EDPW usage tutorials; and (4) an Internet site that allows the distribution of the binaries, the sources, and didactic material as well. Considering the variety of its products, it can be asserted that the project is devoted to researching, developing and implementing an educational commons dedicated to digital photogrammetry.

The project began in 2002 as an undergraduate final project in the Cartographic Engineering Course at The Military Institute of Engineering of Brazil – IME (Coelho Filho, 2002). Presently, it is being developed under the Computer Engineering Masters Program, with emphasis in Geomatics, at The Rio de Janeiro State University (Uerj). E-FOTO's team joins researchers and students from undergraduate and graduate levels with different backgrounds.

This project has three basic principles: (1) entirely free access to component programs and sources, under the GNU/GPL license; (2) free usage of the related documentation and; (3) the availability of sample material. Another E-FOTO's aspect that must be emphasized is its self-learning philosophy which considers 3 levels of interaction between users and the project: level 1 is dedicated to beginners, level 2 to regularly subscribed students, while level 3 to the ones able to develop and to research new functionalities and algorithms.

The direct involvement of undergraduate students of computer engineering brings to the project another interesting feature: the human resources formation in free software development under collaborative environments. At anytime during the software development process, the improvement of the skills of its developers is a major concern. The following sections are dedicated to the presentation of E-FOTO's products.

3.1 The educational modules of the EDPW

Figure 1 presents an overview of a DPW's workflow. Through the decomposition in horizontal direction of this figure, the workflow can be divided into 3 groups: (1) input data; (2) photogrammetric processing; and (3) geospatial output data. The EDPW comprises 7 modules, each one designed to teach one step of photogrammetric process needed to operate the previously mentioned groups (2) and (3).

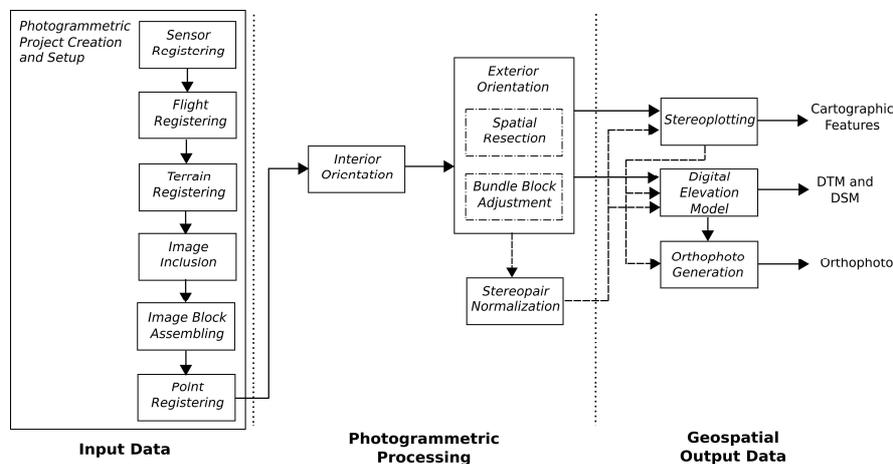


Figure 1. Overview of a DPW workflow

Figure 2 shows the project modules: (a) image rectification; (b) inner orientation; (c) exterior orientation; (d) phototriangulation; (e) stereogram normalization; (f) digital stereoplotter; (g) digital elevation model extraction and orthorectification.

Aided by this EDPW, users can intuitively accomplish the process and observe both the results and the respective quality parameters. Thus, it makes users able to the practical application of the theory shown in classroom and present in the literature.

3.2 Digital Photogrammetry Book

This book is an improved version of a former e-book about this subject that was produced in the early beginning of the project. The book Digital Photogrammetry written by (Coelho Filho and Brito, 2007) brings the basic theoretic foundations about this theme with no need of previous background. Most of its chapters are dedicated to the mathematical models of the photogrammetric process and to their geometric interpretation. Besides the previous mentioned authors, some of the book chapters count with the coauthoring of other project members. It should be stressed that it is the only photogrammetry book edited in Brazil with a full digital approach. In addition, although the book can be purchased in cost price at the Rio de Janeiro State University Publisher, it can be also downloaded free of charge.

3.3 Usage Tutorials

Several software usage tutorials are also available in order to complement the theoretical documentation. Such tutorials guide the step-by-step utilization of the modules. If employed alongside to the book, they permit the comprehension and

approximation between theoretic and practical aspects of this theme.

3.4 E-FOTO's Web Page

E-FOTO's web page, <http://www.efoto.eng.uerj.br>, gathers and gives access to all project products, including scientific publications. That is a mean to achieve the project principles of liberty and self-learning. It also paves the way for improving both communication and cooperation among developers and users community. Such collaborative philosophy is underlain on the Internet, whose existence has facilitated the coordination of volunteer developers around the world, to produce open source solutions (Nichols and Twidale, 2003).

Besides the following mentioned products, the project brought about: four master thesis; seven undergraduate projects; and a number of papers published in scientific congresses.

3.5 Considerations about the E-FOTO educational focus

One important issue for E-FOTO project is self-learning. To give support to that, students have free access to the previous mentioned products, can interact one to each other and develop software solutions for digital photogrammetric problems. The main goal of this self-learning focus is to stimulate students in the exploitation of available E-FOTO resources and to build mental connexions throughout practical activities.

In addition, the on going development of an e-learning tool brings about the discussion of the pedagogical aspects of the E-FOTO project. We notice that, in a broader sense, the teaching of engineering is not based in a pedagogical project aiming at the holistic and critical formation of the students, but mainly focused on technical knowledge. Indeed, at universities, it is not

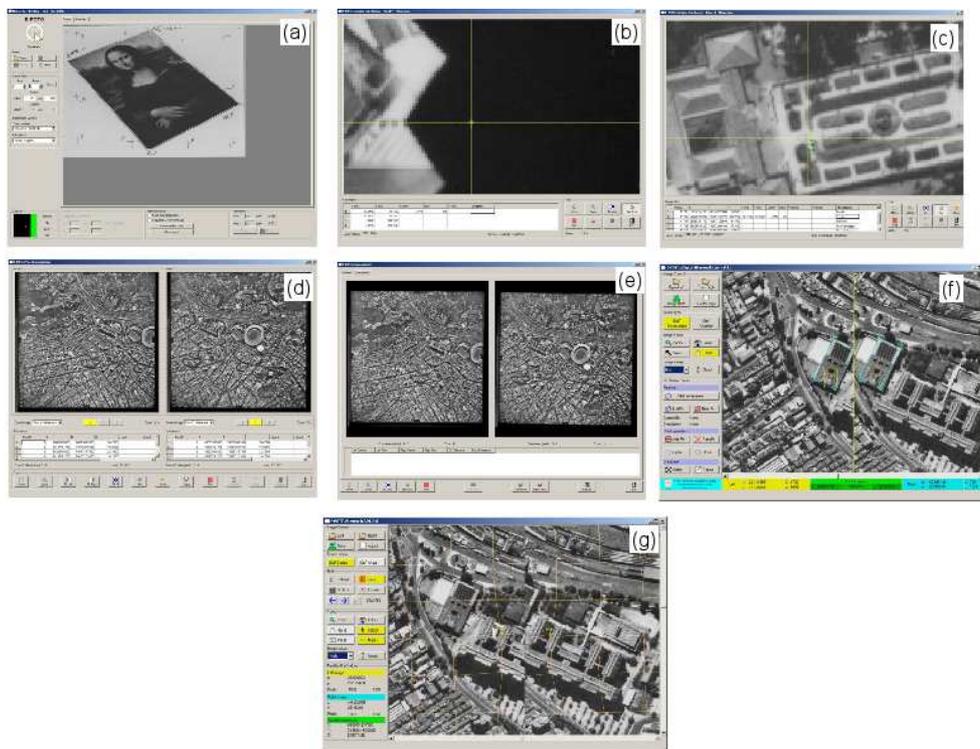


Figure 2. EDPW Modules (a) rectification; (b) interior orientation; (c) exterior orientation; (d) phototriangulation; (e) stereogram normalization; (f) digital stereoplotter; (g) digital elevation model and orthorectification.

unusual the application of an antiquated pedagogical approach based on a poor technical view of learning: students are considered as “tabula rasa” and regarding their evaluation professors rely primarily on memory training.

On the other hand, E-FOTO’s principles require a distinct pedagogy, where students are active actors of the learning process. A theoretical basis of this point of view is the constructionist theory (Papert, 1990). This theory considers that our knowledge is not “about the world”, but “part of the world.” Knowledge is not viewed as a fixed object, but as a common good that is constructed collectively. In such process, each individual is supposed to bring his/her own experience about the subject. Besides, this approach emphasizes the need of stimulating projects in which students, professors and specialists have different responsibilities to reach out a common aim. The objective is to create learning communities concerned with collaborative practices in the real world. In such kind of environment, students assume part of the responsibilities for their own learning and the development of their metacognitive competences.

Collaboration is the key-point to constructionist theories. When people work in a collaborative way, they bring their own structures and perspectives to this activity. They can analyse a problem from different points of view and negotiate and produce meanings and solutions based on this shared comprehension.

The main goal of E-FOTO e-learning tool, currently in its early stage of development, is to deep the adoption of the constructionist learning approach. This requires a broader offer of spaces for the participation and cooperation, to stimulate the formation of communities directed to practice in real world problems – respecting previous academic and personal experiences of students – and the representation of the proposed problems in different formats by means of graphical, mathematical or computational solutions.

4. CONCLUSIONS AND FUTURE TRENDS

The E-FOTO project offers several contributions to society. The most important is the development of an environment for teaching and research, which has great importance for digital photogrammetry. The project allows students and researchers becoming familiar with the use and development of photogrammetric algorithms. In addition, E-FOTO overcomes the limitations imposed by proprietary software producers that keep hidden the photogrammetric knowledge.

E-FOTO’s philosophy is inspired by free software philosophy, but brakes out its bounds. Together, its products bring about an educational commons aiming at the socialization of digital photogrammetry knowledge. According to (Silveira, 2007), the idea of commons brought a revolution in the symbolic production of mankind which has the ability to expand freedom, creativity and democracy. E-FOTO is an example of this.

The research framework developed by the project is consolidated and available. As a consequence, promising trends arise. First, it is the evaluation of end users’ interactions with the platform, in order to collect qualitative and quantitative educational results. Another aspect is the development of a tool for e-learning. A key aspect in the E-FOTO educational design was the idea of self-learning, but this idea has evolved to the development of tools for assisted learning. The general idea of

an e-learning environment for the E-FOTO project is to integrate the already developed educational contents and tools to promote educational activities. This trend has just started. The aim is to produce a dynamic, interactive and self-explanatory remote educational web site using free software. It is intended to be an opportunity to offer the society access to an on-line environment, including virtual classrooms, evaluation, self-evaluation, communication channels for cooperative work and virtual communities.

REFERENCES

- Brito, J. L. N. S., Coelho Filho L. C. T., 2005. The E-FOTO Project - A Digital Photogrammetric Softcopy Kit for Educational Purposes.,” In: *Proc. 6th Geomatic Week Proceedings*, Barcelona, Spain.
- Brito, J. L. N. e S., Coelho Filho, L. C. T., Silveira, F. J. C.; Mota, G. L. A., Bernardo Filho, O., Ribeiro, J. A., Silveira, M. T., Fonseca, R. J. M., 2006. Projeto E-FOTO: O Desenvolvimento de um Ambiente Integrado para o Ensino de Fotogrametria Digital em Software Livre. In: *Anais da Workshop de Software Livre*, Porto Alegre, Brazil.
- Coelho Filho, L. C. T., Brito, J. L. N. e S., 2007. *Fotogrametria Digital*. EdUERj, Rio de Janeiro, 196 p.
- Dowman, I.J., Ebner, H., Heipke, C., 1991. Overview of European Developments in Digital Photogrammetric Workstations. *Photogrammetric Engineering & Remote Sensing*, 58(1), pp. 51-56.
- Kraus, K., 2000. *Photogrammetry v. 1: Fundamentals and Standard Processes*. Dümmlerbuch, Vienna, 398p.
- Longo, W. P., 1996. "Reengenharia" do Ensino de Engenharia: uma necessidade. *Revista Segurança & Desenvolvimento*, 220, pp. 13-16.
- Mota, G. L. A., Brito, J. L. N. e S., 2005. Projeto Tomógrafo: Cálculo do Volume de Nódulos Pulmonares a Partir de Imagens de um Tomógrafo Helicoidal. Projeto de Fixação de Pesquisador FAPERJ, Rio de Janeiro, RJ, Brazil.
- Nichols, D. and Twidale, B., 2003. The Usability of Open Source Software. *First Monday*, 8(1).
- Papert, S., 1990. *Introduction: Constructionist Learning*. Idit Harel (ed.), MIT Media Laboratory , Cambridge, MA .
- Phem, S., Grabmaier, K., 2004. Refresher Course on Digital Photogrammetry. In: *Proceedings ISPRS Congress, Proceedings of Commission VI*, Istanbul, Turkey.
- Silveira, S. A., 2007. Redes virais e espectro aberto: descentralização e desconcentração do poder comunicacional . In: Silveira et al. *Comunicação digital e a construção dos commons: redes virais, espectro aberto e as novas possibilidades de regulação*. Editora Fundação Perseu Abramo, São Paulo. 176 p.