

# THE E-FOTO PROJECT: AN EDUCATIONAL DIGITAL PHOTOGRAMMETRIC WORKSTATION

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### ABSTRACT:

This work aims to establish a research project involving the development of digital photogrammetry routines, using a high-level programming language, with the objective of developing an educational digital photogrammetric workstation at the Department of Cartographic Engineering of the Military Institute of Engineering. The concept of an educational digital photogrammetric workstation deals with two main pillars: the freedom of use of its many components, and the self-teaching approach, allowing its use with no cost by anyone who is interested to do it. From this concept, some support work is developed, like the software help, the online tutorial on digital photogrammetry and the support homepage of the Digital Photogrammetry Area of the Terrain Imaging Workgroup. Also, this paper intends to provide support for the use of the workstation by other researchers who are interested in working on future steps of this project.

## 1. INTRODUCTION

### 1.1 Brief History

For many years, photogrammetry has been the only trustable source of cartographic data. As a consequence, many optical-mechanical solutions were presented, leading to the well-known analog (and, later, analytic) aviographs. By the ending of the eighties, a handful of enterprises had the monopoly of the sector, while others, smaller ones, were also trying to share that market, offering their own solutions. All of those solutions, though, required a certain level of mechanical and optical components, turning the machines very expensive for the general public, and making them only available to those who had “serious cartographic work” to be done (normally enterprises and government institutions) and could afford their prices. Universities and research centers, especially those that are located in developing countries, never could have the opportunity to have the most advanced (and most expensive) machines. No additional information was given on the way they were projected and built. This fact has made the teaching of photogrammetry restricted to the theoretical principles and to the use of second-hand instruments available in those countries. During the nineties, a huge revolution in the world of photogrammetry was seen. The first totally computer-based photogrammetric instruments were created, due to advances in computer technology, which allowed real-time manipulation of large image files (also named “softcopy photogrammetry”). The independence of machinery, theoretically, would make the so-called “Digital Photogrammetric Workstations” cheaper. However, their prices remain very high, leading to the same problems and deficiencies that once happened. The new technologies depend only on digital computers, programming languages, and people to develop the routines that perform the same operations that once needed huge mechanisms to be executed. Fortunately, those routines have been always well described theoretically, leaving the efforts to its implementation.

### 1.2 Digital Photogrammetry at IME

The Military Institute of Engineering (IME) has been doing research on the implementation of softcopy photogrammetry routines, and the development of different approaches to them. The Institute holds the position of one of the pioneers of the introduction of softcopy photogrammetry techniques in Brazil. In fact, during the past five years, a considerable bibliographic production was written and published by its students (undergraduate and graduate) and professors. Small programs, which independently could perform interior and exterior orientations, spatial resection, spatial intersection, stereo-restitution, semi-automatic extraction of a DEM and ortho-rectification were developed as a result of those studies. The mandatory course called “Digital Photogrammetry” exists since 1998 and all students have implemented all these routines, using appropriate mathematical software for that.

### 1.3 Motivation

At IME, the photogrammetric resources are somehow limited, being restricted only to an old DVP Station and to a new ImageStation SSK Kit. These solutions are efficient at performing the photogrammetric operations, but they can be used only by one student at a time, due to hardlocks and other restrictive technologies. The ideal situation would be a system that could be used by many students in as many computers as necessary, at same time.

Although some initiatives at IME on digital photogrammetry were presented, all those projects were generated separately, without much interaction among them. So, there is still a need to converge all this effort into one integrated research project.

The natural way to solve these problems was the development of a photogrammetric softcopy kit. This kind of project may be compared to a puzzle: it involves basically three pieces: people (the staff), a programming language and computer resources. As an integrating piece, there is the knowledge acquired over the years, through previous research and experiences.

### 1.4 Current Activities

This expertise acquired over the years led to the current

development of the concept of an educational (or academic) digital photogrammetric workstation. That workstation should be composed by a set of software, capable of performing photogrammetric operations, accompanied by appropriate literature. It should also be not copyrighted, making it accessible to all people who are interested in it.

The project, called E-FOTO, aims to develop and manage an educational photogrammetric softcopy kit – a concept that will be better explained on the next topic.

## 2. METHODOLOGY

### 2.1 What is an Educational Digital Photogrammetric Workstation (or Softcopy Kit)?

This concept is not very widespread yet, and multiple interpretations for it might appear as time goes by. What we intend here is to present the E-FOTO approach for this concept, which is what we think an Educational Digital Photogrammetric Workstation should be.

An ordinary workstation has many modules, which represent the main photogrammetric tasks. For E-FOTO, the following modules were conceived: pre-processing, project manager, camera configuration manager, interior orientation, aerotriangulation (spatial resection + spacial intersection), extraction of a DTM, and orthorectification.

For the educational approach, two main pillars were established (Figure 1.): the total freedom of use of its components and the self-teaching approach.



Figure 1. E-FOTO's main pillars

The algorithms are being developed using the C++ programming language, and the multiplatform (Linux, Win32, Mac) GUI toolkit Qt 2.3.0. Under Linux, Qt is free, and this version of E-FOTO is released under the already famous GNU GPL (General Public License). For Microsoft (R) Windows, Qt has a non-commercial version, which is not GNU compliant. Because of this, we do not encourage the usage of this version, but, as we provide the source code, it can be compiled under these two platforms, with no restrictions.

The self-teaching approach (which concentrates as much time as the programming tasks) is divided into three levels of learning (Figure 2.).

The first level is for the users who are interested only in doing the photogrammetric operations, executing the software applications. Accompanying them, there is an explanatory online help, to solve the main problems and doubts found when operating the software.

Having some deeper doubts, the user might want to know how digital photogrammetry works: its concepts, routines and different approaches. The level 2 user will also be interested in reading the digital photogrammetry tutorial. It focuses on the theory behind digital photogrammetry, and on the algorithms used in E-FOTO. The tutorial is organized in a way that no

previous knowledge of photogrammetry is needed, and those who are not willing to learn about analog and analytical photogrammetry will normally understand the text, as if it were a newly born subject. By the ending of each chapter, there are explanations of the algorithms, and the best source codes selected over many implementations made by the current and former students at IME. Also, the user can access the Digital Photogrammetry webpage at IME's main site, where the projects developed during these 5 years of digital photogrammetry at IME are listed. Some of them can be downloaded as .pdf documents. If the teacher wants, or even if the student is really willing to contribute, he (or she) will also take a look at the source code (which is commented), to better understand how the software works.



Figure 2. E-FOTO's three levels of learning

At this point, the student might be able to develop a new module (which could be an assignment, for instance) or upgrade the old ones. This is level 3. People who get into this level become developers, making part of the E-FOTO team. It is our desire that all users reach this level, but no one is obliged to do so. He (or she) will be at the level that best fits its own needs.

The final goal of this 3-level user approach is to provide to the student a means of learning digital photogrammetry in a whole way. The student will be able to read about it, and to understand its principles. Also, he or she will have the possibility to use the software – perhaps the first opportunity to see how a modern photogrammetric system works. If the teacher wants, or even if the student is really willing to contribute, he (or she) will get the source code, to better understand how the software works.

As a consequence, the student will be prepared for a totally digital environment. Digital photogrammetry would not be a mystery to him, and the gap between the concepts being taught at universities and the reality at enterprises will be minimized. More important than that will be the ability to think, and to develop a critical sense, because the student will not be a mere user; on the contrary, he (or she) will have learnt the concepts behind those workstations. In many countries and universities, where the teaching of photogrammetry is limited to some old instruments and theoretical equations, this would be a great improvement.

### 2.2 Software Development

The following modules have been developed and are presented in their alpha version in Portuguese and English:

The image viewer (Figure 3.) allows easy viewing and zooming of images. It is only a test program, but its binaries may be distributed too.

The project manager (Figure 4.) generates a project configuration file, containing the main parameters of the project, such as: coordinate system, linear units, angle units and flight and statistical parameters.



Figure 3. E-FOTO Image Viewer

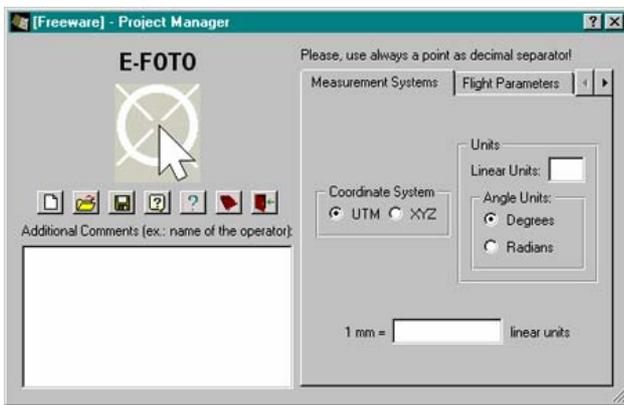


Figure 4. E-FOTO Project Manager

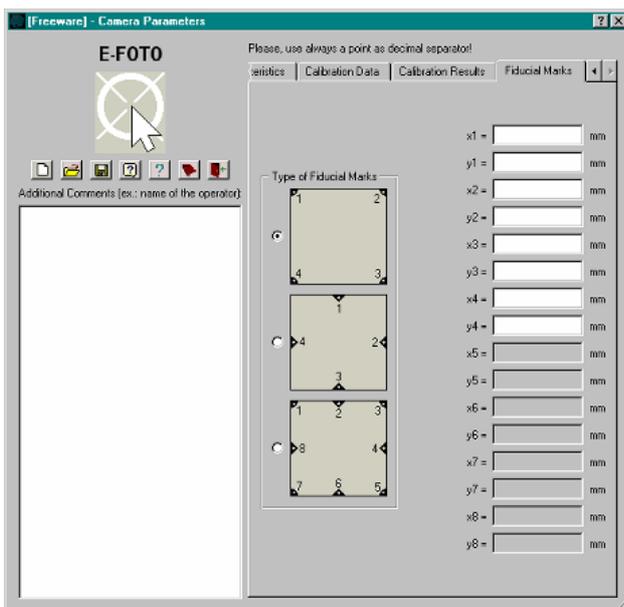


Figure 5. E-FOTO Camera Calibration Module

The camera calibration module generates a camera configuration file, which basically comprises all information contained in the calibration certificate (Figure 5.).

The interior orientation module (Figure 6.) performs this operation for a 4-mark or 8-mark image, through automatic or manual recognition of fiducial marks. It uses two models: affine and similarity.

The photo triangulation module (under development) organizes the image files according to their spatial distribution (i.e. blocks) and performs the exterior orientation (through spatial resection), first, to determine all flight parameters for all images (i.e.  $X_0$ ,  $Y_0$ ,  $Z_0$  of the perspective center and  $\phi$ ,  $\omega$  and  $\kappa$  – attitude angles of the camera). Then, it does the spatial intersection, in order to acquire X, Y and Z for all points selected.

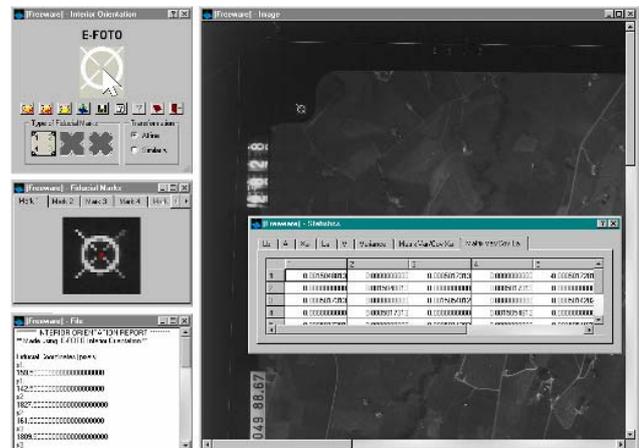


Figure 6. E-FOTO Interior Orientation Module

The other modules have not been developed yet, but more information on their development, as well as updates, may be found at the E-FOTO project website: <http://e-foto.sourceforge.net>.

### 2.3 Documentation

There are four main documents that are being developed as part of the E-FOTO project: the online help, the tutorial on digital photogrammetry, the digital photogrammetry homepage and the additional text files that contain relevant information on some aspects of E-FOTO.

The online help (Figure 7.) comes with the source code, or with the binaries. It is a simple .rtf file with the main instructions for the module that corresponds to it. In order to be easily accessed through E-FOTO's main menu, it should be in the same directory that contains the executables. It is available in two languages: Portuguese and English.

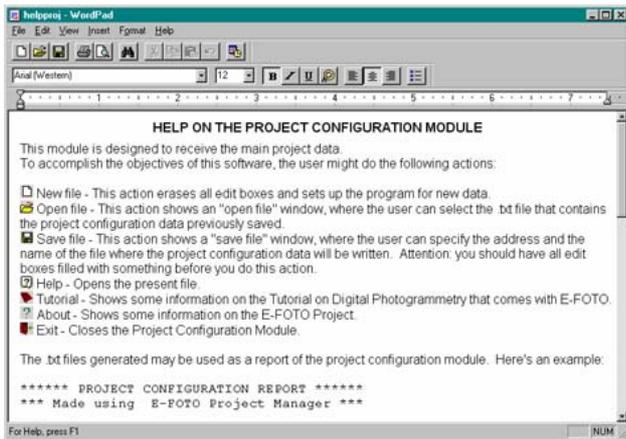


Figure 7. Online help

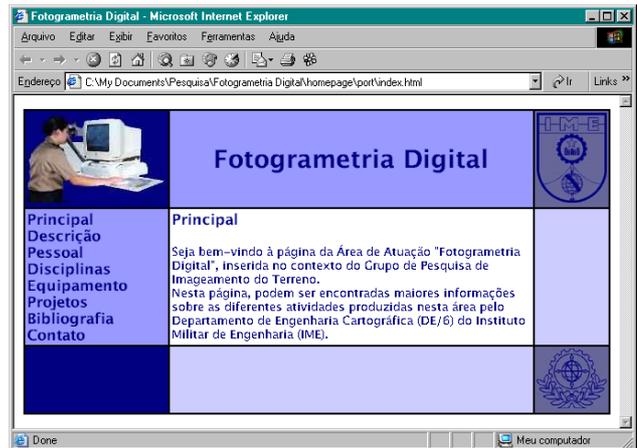


Figure 9. The Digital Photogrammetry Homepage

The tutorial on digital photogrammetry is basically an e-book, which consists of 10 chapters (Figure 8.) and 4 appendices. The chapters are:

- ≈ 1. Introduction to Photogrammetry
- ≈ 2. Basic Principles of Photogrammetry
- ≈ 3. Interior Orientation
- ≈ 4. Image Correlation
- ≈ 5. Exterior Orientation
- ≈ 6. Aerotriangulation
- ≈ 7. Image Rectification and Normalization
- ≈ 8. Automatic Extraction of a DTM
- ≈ 9. Orthorectification
- ≈ 10. Digital Restitution

And the four appendices are:

- ≈ I. Flight Project
- ≈ II. Digital Photogrammetry using Satellite Imagery
- ≈ III. Close Range Digital Photogrammetry
- ≈ IV. New Technologies and Tendences for the

Future

Currently, six chapters have been written and revised: 1 to 5 and 7. Unfortunately, due to the high quantity of pages, they are available only in Portuguese.



Figure 8. The Tutorial on Digital Photogrammetry

The digital photogrammetry homepage contains important information on the past and current activities at IME that have been doing in this area of knowledge. There, several papers can be downloaded. Unfortunately, not all of them have an English version, but, as many articles were presented in international symposia, they might be useful.

The text files can be found in both languages. They are available at the sourceforge project page, and are described as “documentation”. Some examples are: compiling instructions, the GNU GPL text and other information that might be found useful.

### 3. PARTIAL CONCLUSIONS

At this point of the project, only a few real tests have been done, and all software generated have been tested using the material that is available at the Department of Cartographic Engineering. The main code errors have been fixed, but, for E-FOTO, the main objective is not to test the algorithms (which we already know that work) but to test the benefits of its educational approach. An intended test will be done with IME's fourth year students during the next semester.

But, even with these scarce results, some important conclusions may be described. One of them is the beginning of the production of literature in digital photogrammetry at IME. It is expected that the tutorial will be used not only by E-FOTO users, but also as a normal book for our students.

Another important fact is the use, for the first time, of free, non-proprietary software. Using different operational systems such as Linux, free libraries, such as Qt, and the well-known and widespread C++ language brings a wideness of use never seen before in any of our projects. E-FOTO can be acquired and installed freely, without any kind of proprietary dependency, turning it more democratic than most kinds of photogrammetric software found nowadays.

Finally, an excellent feed-back of our first users helped stimulate the advance of the project. We hope that in the near future, more people would contribute to the development of the E-FOTO project, as level 1, level 2 or level 3 users.

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