THE E-FOTO PROJECT - A DIGITAL PHOTOGRAMMETRIC SOFTCOPY KIT FOR EDUCATIONAL PURPOSES

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ABSTRACT:

This paper shows the current efforts in order to develop a digital photogrammetric softcopy kit which intends to provide a link between theory and practice in the field of Photogrammetry. These efforts have started in 2002, with the development of the first modules of the E-Foto kit: image viewer, project configuration, camera parameters, interior orientation and digital mensuration. The project was based upon a two-principle approach: freedom of software and self-teaching. This means that all software are delivered under a free license (in this case, the GNU GPL), which turns it accessible to users who might compile and use it, study its code or even develop new modules for it. The second principle relies on a considerable amount of teaching material that accompanies the software, including an on line help, the e-book on Digital Photogrammetry and the project's support homepage. Based on these resources, the user will be able to study the main photogrammetric principles, how they work and how to use them. Its main objective is to diminish the gap that exists nowadays between the teaching of Photogrammetry and Remote Sensing in universities and Research Institutions of developing countries and the high-tech expensive systems that are used under the spatial data production environment. Currently, there are five modules ready to use, in English and Portuguese, and one under development. Both Linux and Windows versions are available. Thee-book on Digital Photogrammetry is available only in Portuguese and is distributed as a series of portable document files (pdf's).

1.INTRODUCTION

1.1 Photogrammetry: a Brief History

Photogrammetry can be regarded as “the science and technology of obtaining spatial measurements and other geometrically reliable derived products from photographs” (Kiefer, Lillesand, 2000). Simply put, it concerns any kind of reconstruction of the tri-dimensional space through bi-dimensional images.

Photogrammetry, nowadays, has many uses, such as: architecture, quality control, 3-D modeling and, of course, cartography. By the way, during many years, it was considered the most practical form of obtaining reliable topographic maps. That's why most mapping agencies still rely on its use for such purposes.

Its main mathematical principles were established many years ago, and first implemented through optical and mechanical instruments. Those were, of course, very expensive, and the technology concerning their design and construction was somehow hidden. Science is a stone wall and one cannot build it all at once – that's why most photogrammetric instruments were built by the already active optical instruments industries who had the expertise in implementing complex machinery. Those who have tried to start building such aviographs from the scratch did not succeed.

Most solutions were limited only to specific types of cameras and because of that, they were not very versatile. Everything had to be specifically designed for that particular photogrammetric system, otherwise, it could not be used. Those reasons (and many others) made photogrammetry a very expensive science. Poor countries had

problems in acquiring those instruments, and in most cases they were at first destinated to their mapping agencies. University and research centers most of the time had to deal with second-hand equipment. This contributed to the lack of knowledge many professionals presented when having to use the most modern photogrammetric instruments.

In the early nineties, however, a huge revolution was seen. It was the first time that computers were powerful enough to handle efficiently large image files. This turned available the first completely computer-based photogrammetric systems, which made, for the first time, Photogrammetry independent from optical and mechanical implementations. This new field (Digital Photogrammetry) relied on three basic principles: computer hardware (advanced enough for near-real time image processing), photogrammetric software (mathematical implementations of the principles long ago discovered) and knowledge (to implement and use the software). Even at that time, the sum of all three factors was considerably cheaper than a single mechanical instrument. Some companies, many of them still new to that field of science, have invested heavily on digital implementations for photogrammetric principles, and lead the market to completely change the way tri-dimentional photogrammetric data were produced.

Unfortunately, prices remained high and the access to digital stations continued to be limited only to those who could afford it. However, the technology was now open to everyone who had those three principles (hardware, software and trained personnel) already described.

Based on previous experience, the idea or developing a photogrammetric softcopy kit at the Military Institute of Engineering was born. The details concerning its development will be better described on next topic.

1.2 The E-FOTO Project

Several B.Sc. and M.Sc. final projects and thesis involving Digital Photogrammetry were carried out during the last eleven years at the MIE. This led to the idea of creating a set of photogrammetric software for our own use, according to the routines and algorithms that were implemented since 1993.

Unfortunately, there was no point in creating a softcopy kit to compete against well-known software, like those that were already been used at the Department of Cartographic Engineering (ZI SSK and DVP). If something had to be developed, it should be a modest project and have a different approach to the subject. That is where the whole “educational” concept fits in.

The idea behind the E-FOTO project was to offer a simple set of software that could help our students understand the principles behind Photogrammetry. Engineers are supposed to comprehend how technologies related to their field of knowledge work, and if they were presented to a self-teaching software, it would be a lot easier to make them understand and extract the maximum amount of information from full-featured commercial systems.

This concept sounded right and soonly evolved to the current model, which can be explained by the “two-pillar approach” (Brito, Coelho, 2002). This means that the E-FOTO project is based on two main principles (pillars): freedom and self-teaching.

“Freedom” means that the software is freely distributed, according to the principles devised by the Free Software Foundation. Its license is the GNU GPL (Gnu's Not Unix General Public License) one, which means that the users may distribute the software, look at its source code and modify it. It is also free of charge.

“Self-teaching” means that some sort of help is available, so, the user will not be left alone with the software. There's a brief, but explanatory on line help accompanying the software and an e-book on Digital Photogrammetry, which tries to explain its principles according to the software approaches.

The final idea is to lead the students to fully understand the princples behind Photogrammetry – reading the e-book, using the software, taking a look at its source code and even modifing it or developing new modules to it.

The way the whole project is being implemented will be described on next section.

2.DEVELOPMENT

2.1Conceptual Model

First of all, the applications that would take part of E-FOTO should be described. A simple scheme is shown at Figure 1. In order to make the software developed as educational as possible, only the essential modules were included. Each one of them is to be related to a chapter of the e-book that comes with them.
For each module, there should be a useful help file, describing the main tasks that must be performed in order to make the software work properly. This file might be accessed through the main application.
Also, an e-book covering all subjects related to the theme, and paying special attention to the workflow described before must be distributed. It will present full explanations to the concepts the user needs to know in order to explore the science and technology behind Photogrammetry.

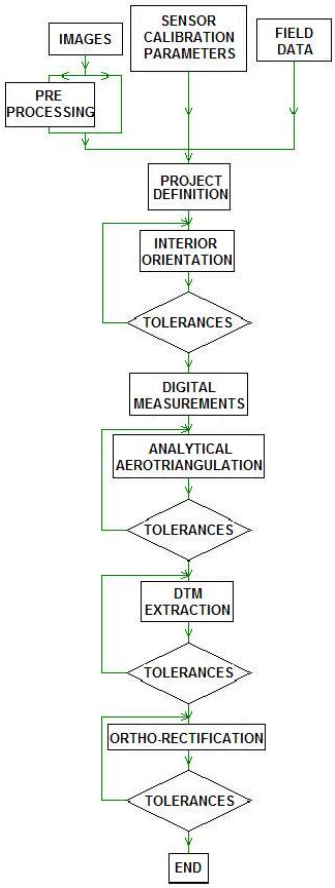


Figure 1. E-FOTO workflow

Finally, these pieces of information should be readily and freely available to all who want to study them.

2.2Implementation

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, the usage of this version is not encouraged, but, as the source code is freely provided, it can be compiled under these two platforms, with no restrictions.

Qt makes easier the hardwork related to developing a software. It already has all sorts of graphic objects, such as buttons, forms, panels, radio buttons and check boxes. It also has built-in mathematical functions, like operations with matrices, that are very useful for any kind of image processing operation. Plus, it is multi-platform, which means that the exact same sourcecode can be compiled under different OS (Windows, Unices and Macintosh), provided that the user has the specific license for each platform (GNU for Unices, freeware for Windows and paid for Macintosh). Figure 2 shows a simple screenshot of one of E-FOTO's modules.
The software is being developed in two languages: English and Portuguese. The code, however, has comments only in English (Figure 3), as it is widely known that English is the *lingua franca* of programming. Qt has some features that make easier internationalization of software generated with it, so, if there is time (and demand), versions in other languages could be benerated.

Figure 2. Sample E-FOTO application made using Qt/C++

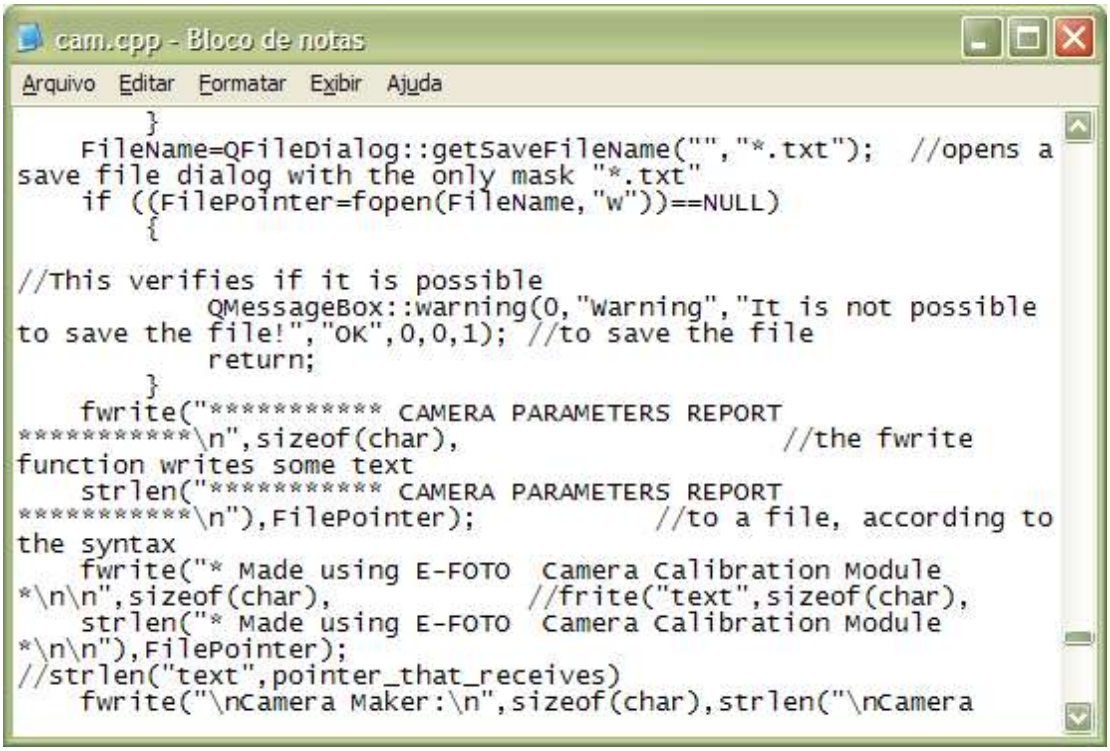


Figure 3. Sample source code (comments are preceded by "//")

A deeper look into each one of the currently developed modules will be postponed until next section. For now,

the implementation of other parts of the project will be explained.
For the on line help, simple html files were used. They do not demand further explanation, mostly because Figure 4 is self-explanatory.
The e-book was indeed the most difficult task. Before it was written, there were only lecture notes on the subject at the MIE. The idea of a full text to completely substitute them took about two years and its appendices are yet unfinished. Currently, there are about 200 A4 pages subdivided in ten chapters: Introduction, Basic Principles of Photogrammetry, Interior Orientation, Image Correlation, Exterior Orientation, Aerotriangulation, Image Rectification and Normalization, DTM Extraction, Ortho-Rectification and Digital Restitution. As the e-book intends to be a part of E-FOTO, there is no point in explaining Analog and Semi-analytical Photogrammetry. Everything is explained according to a fully digital approach and, when necessary, special references to old technologies that might still be in use today are made. This is important: the e-book is about Digital Photogrammetry, and not Photogrammetry. Normally, students have to undergo all less modern photogrammetric approaches before studying their digital side. This e-book tries to explain Digital Photogrammetry from the beginning, without previous knowledge of Photogrammetry at all. The software, help and support page will complement the user's learning experience.

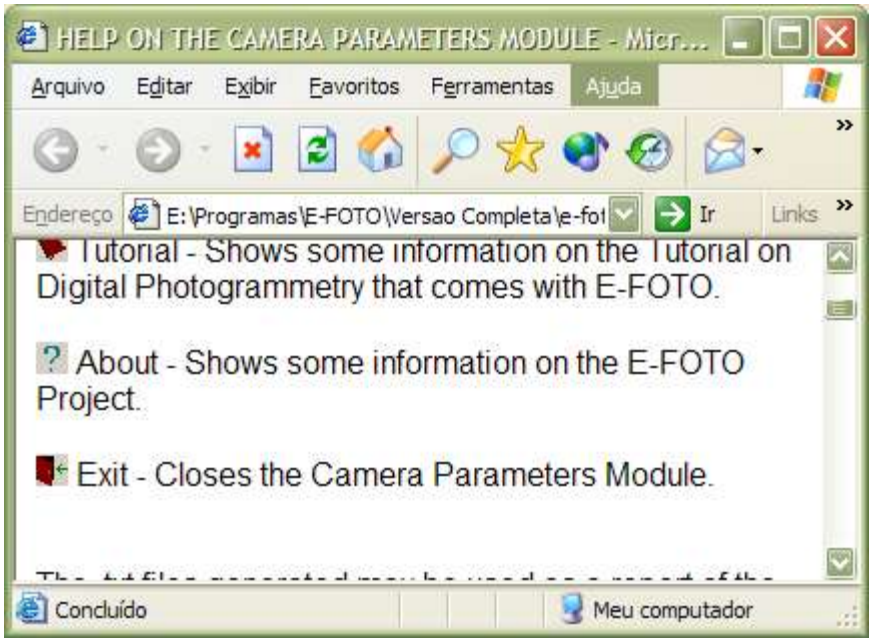


Figure 4. An example of the on line help

Unfortunately, the e-book, distributed through pdf files, is only available in Portuguese. Its translation to English was, and still is a priority for the future. It is a heavy task, though, and for now, way too much time-consuming to be taken.

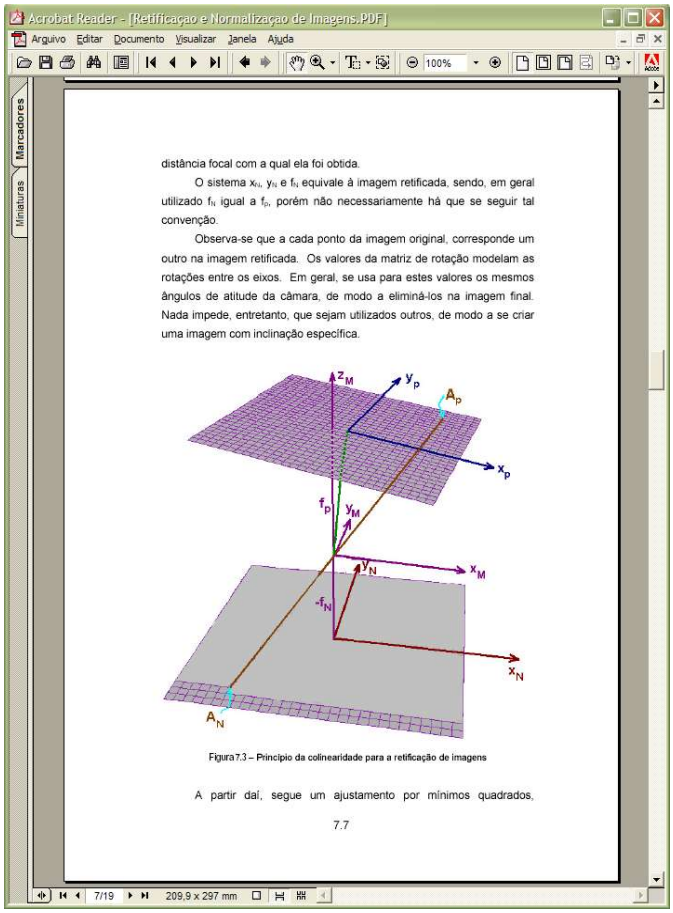


Figure 5. e-book on Digital Photogrammetry

The Portuguese version was considerably successful, however, and the feedback received from the lusophone photogrammetric community was so good that a 2nd edition is already being written. Figure 5 shows a sample page taken from Chapter 7.

As a multi-faceted project, a management tool was almost mandatory, so, the free, web-based SourceForge was used. It provides a CVS Repository (which grants access to every single modification the sources have had) and a free web page. This is actually the page from which WWW users can download the software, the help files and the e-book. Its address is: http://e-foto.sourceforge.net.

3.AN OVERVIEW OF E-FOTO

3.1Using E-FOTO

An example showing the educational approach of the software is briefly shown in the following lines.

Let us suppose that the teacher wants to discuss about camera calibration. He will, then, invite his students to use E-FOTO for that. An ordinary student will click on the "Camera Parameters" button of the main application. The screen shown on Figure 6 will be presented.

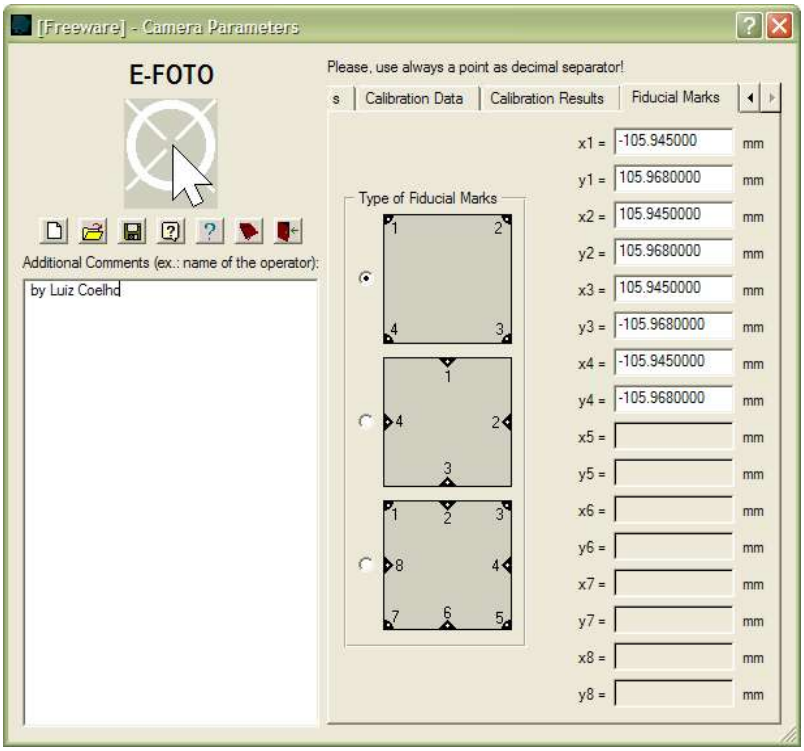


Figure 6. The camera parameters module

Given a sample calibration certificate, the user will complete the blank fields with that information. If he doesn't understand what he is doing, he might also take a look at the theory shown at chapter 2 of the e-book (Basic Principles of Photogrammetry), which describes what every calibration parameter means (Figure 7). Method and procedure names used in the software are the same that are used throughout the book, so, a simple search will return more detailed information on that unknown parameter.

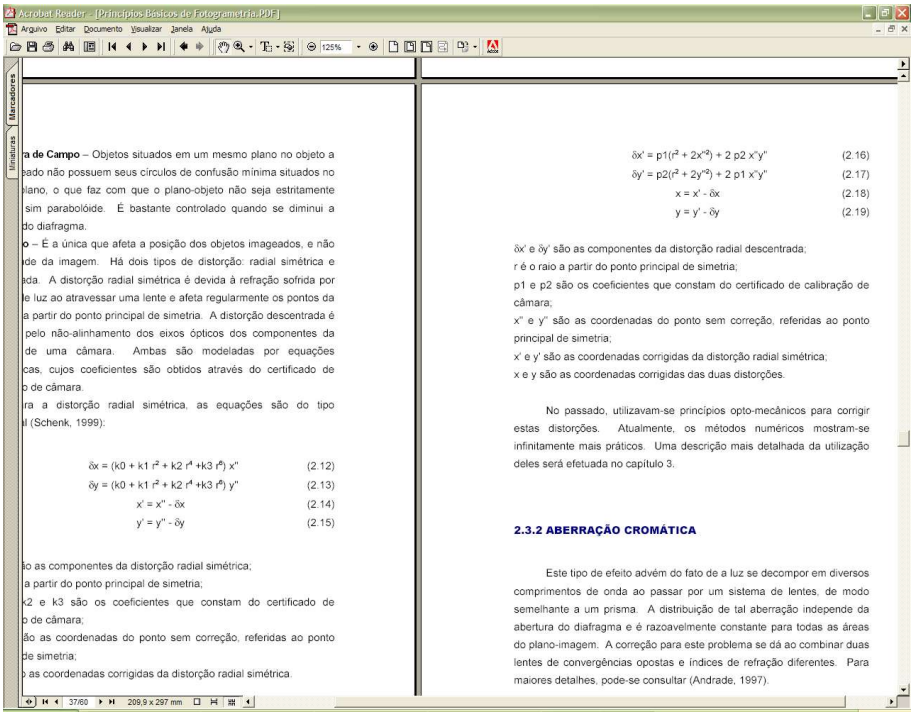


Figure 7. A description of what each distortion parameter means

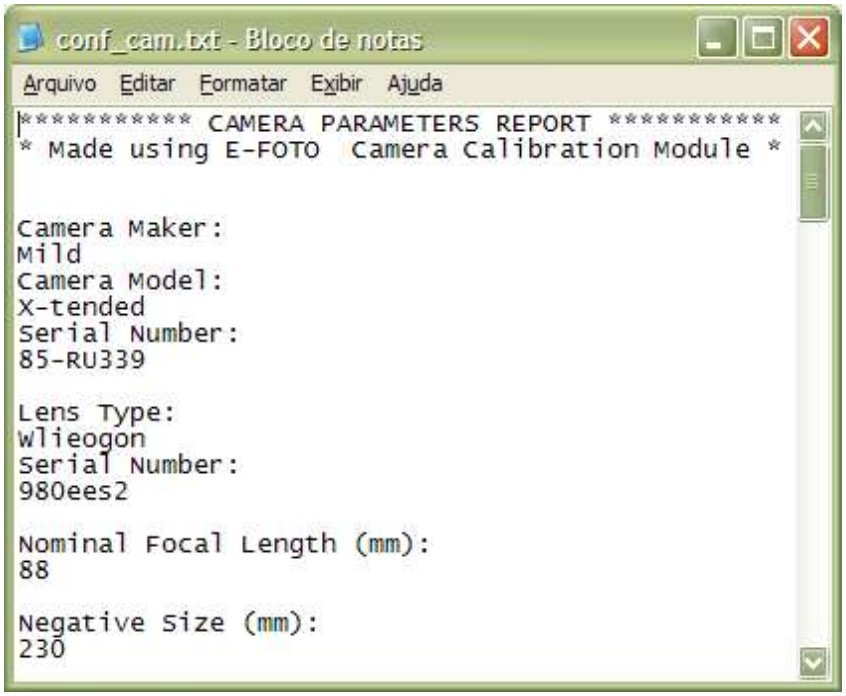


Figure 8. An example of the way E-FOTO stores its information

Another useful piece of information is that E-FOTO generates simple, readable files (stored as txt files). Information generated with E-FOTO is recorded in this manner, so, any file can be easily read (no encrypted or database hidden fields). The teacher can use his students report files as a means of identifying their mistakes. The students can use the files E-FOTO generates as their own reports. An example is the file generated by the Camera Calibration module (Figure 8).

A sample set of data comes with the binaries, so, the student will have, at least, some configuration reports and some images to explore. Moving on, another idea the teacher could want to implement concerns the process called Interior Orientation. He (or the student) will, then, click on the button "Interior Orientation", on figure 2. The interior orientation application will be shown. On the main bar, the user will be invited to open previous project and camera configuration files, then an image (again, E-FOTO comes with a set of ready-to-use files). When opened, the user will be prompted to select its first fiducial mark, and go on or let the program search for similar ones.

At this point, the teacher might recall the "Image Correlation" subject, which deserves an entire chapter of the e-book. Important discussions on how all fiducial marks were located using only one as a sample might appear, and the students will be able to explore the source code and even understand how all those mathematical operations are converted to a computer language (Figure 10).

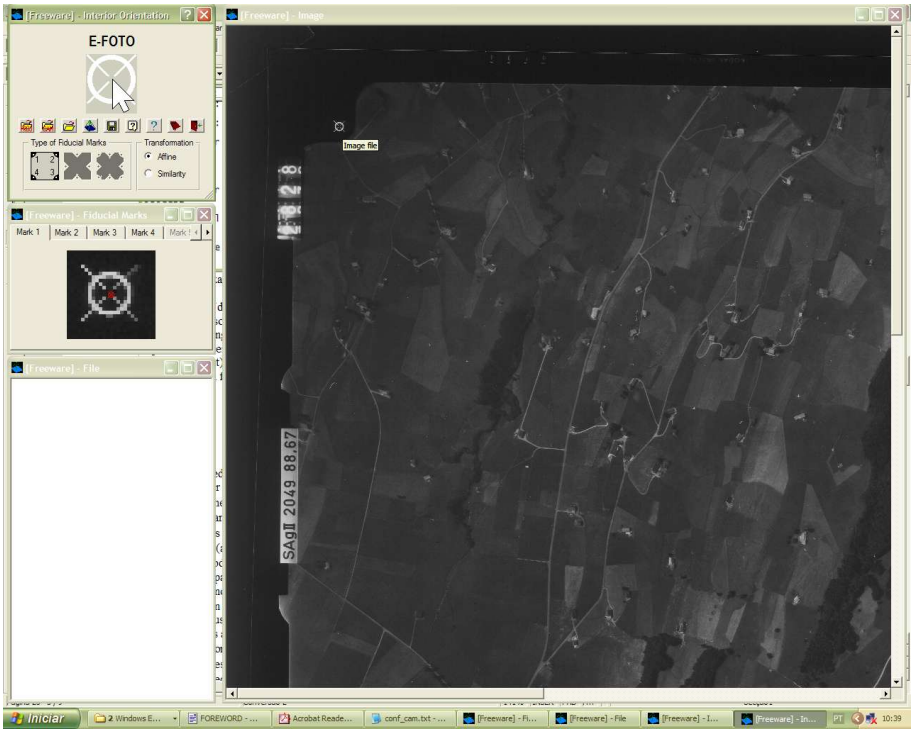


Figure 9. Interior Orientation

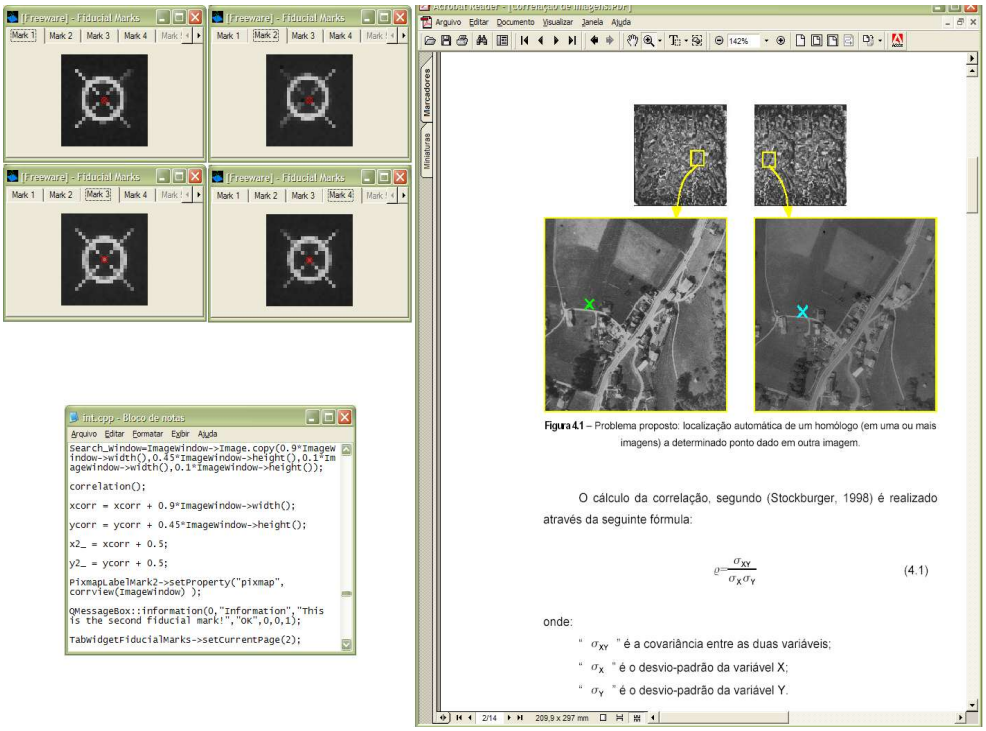


Figure 10. Three useful pieces of information: the automatic correlation output from the software, its theoretical explanation from the e-book and its implementation, from the source code

Another interesting activity would be the comparison between the results obtained from the same fiducial marks, but using two different models: affine and similarity. Again, those are described more deeply on the e-book. The software will present the results as it is depicted on Figure 11.

Although not explained here, due to article size limitations, other applications that are ready to be used (Figure 12) involve project configuration and digital measurements (for aerotriangulation).

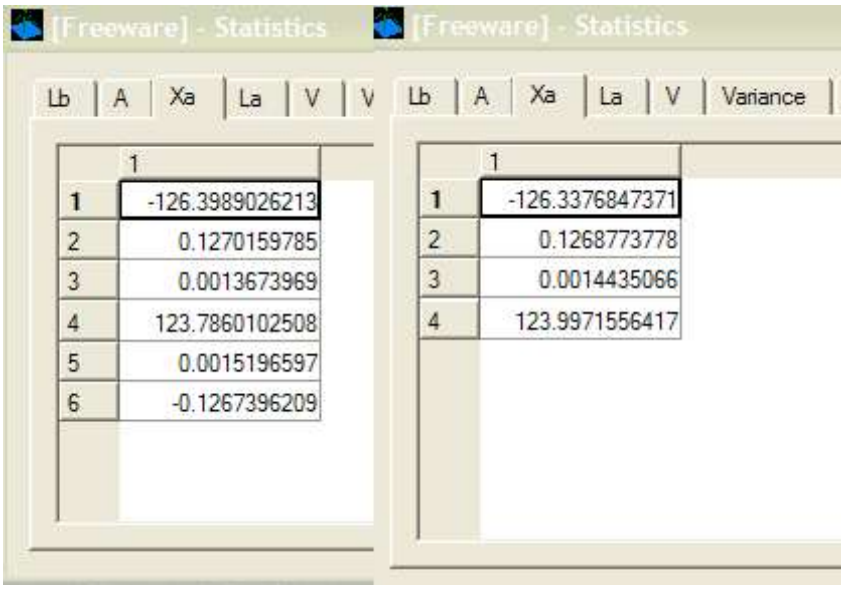
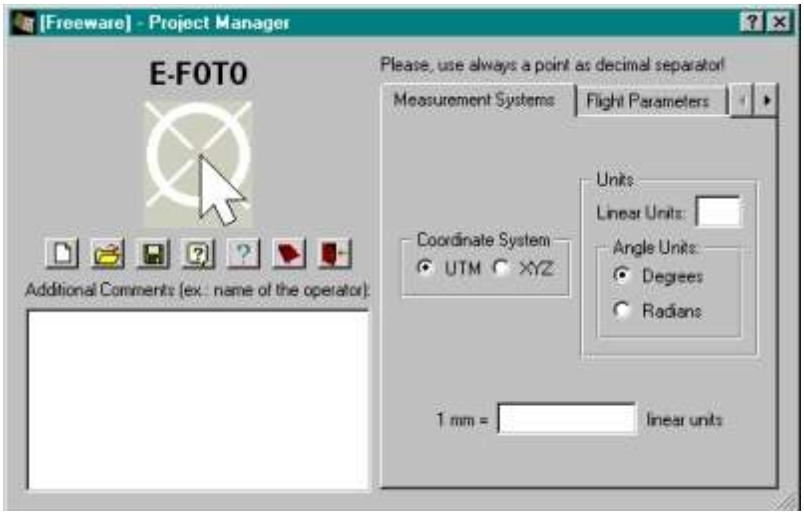


Figure 11. A comparison among different mathematical models

3.2 The Three-Level Approach

Using the tools described before, three levels can be described. The first level is for those 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 e-book. It focuses on the theory behind digital photogrammetry, and on the algorithms used in E-FOTO. 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. 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.



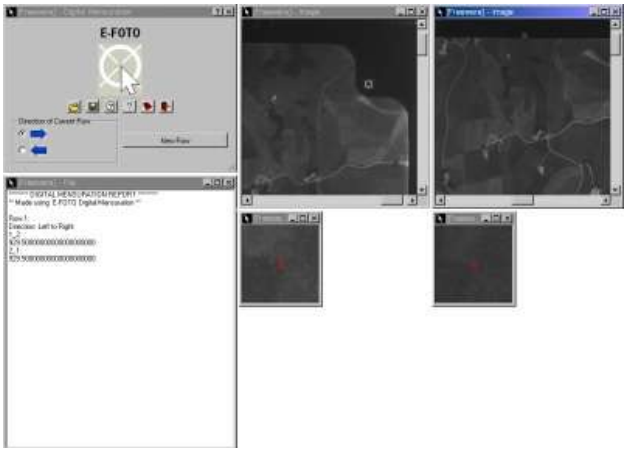


Figure 12. Other software related to E-FOTO

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 would be fantastic 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 his 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.

4.CURRENT ACTIVITIES AND CONCLUSION

4.1Current Activities

At the beginning of 2003, the author was transferred to the 4th Surveying Division, in Manaus, and can no longer act as directly as he used to. In spite of that, Prof. Jorge Brito has taken the project's activities alone. After a slow restart, the project has now seven undergraduate and two graduate students working on it. Also, the National Council of Education and Research has decided to finance the project. This brings new horizons to E-FOTO and its community.
Currently, the teaching material is being regularly used at the MIE and the Rio de Janeiro State University. Several people from other institutions have visited the E-FOTO web page, downloaded the material and gently forwarded us useful evaluations and suggestions.

4.2Conclusion

The modern World is constantly changing and education is one of the last things that do not get obsolete. However, its techniques must be adapted to newer resources and environments.
If taken alone, ideas such as writing an e-book on a special subject, developing free and multi-platform software and distributing information through the Internet are not original. However, bringing them together and applying the whole concept to Photogrammetry – a science that has suffered from so many abrupt changes in the last fifteen years – is, for everyone who has taken part of the E-FOTO team, a huge necessity. Today, many geo-software packages offer photogrammetric features, but their users most of the time have little knowledge of what they mean. As

Photogrammetry gets widespread, its knowledge must follow its popularization.

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