

Building an On-line Resource for Computer Vision Educators

Bruce A. Maxwell

Swarthmore College
500 College Ave.
Swarthmore, PA 19081
maxwell@swarthmore.edu

Abstract

Computer vision is a difficult subject to teach. One of the most difficult things to do when teaching computer vision is develop good assignments. Many of us have both succeeded and failed in this task. Computer vision can also be an expensive topic to teach, both in terms of equipment and the time required to set up hardware and acquire high-quality data sets. Different institutions have different capabilities, but few have the variety of resources necessary to cover all of the topics in a computer vision course. This paper describes an ongoing project to bring the successes and capabilities of many institutions together into a comprehensive on-line resource for computer vision education. This resource will contain vetted assignments and homeworks, complete with data sets and solutions. In addition, it will contain educational resources such as lecture notes, links to other computer vision courses, and reviews of textbooks, software, and hardware. We will accomplish this objective by collecting materials from computer vision educators, developing new materials, and organizing and building a comprehensive web site from which to serve them.

1 Introduction and Goals

This is a forward looking paper with the goal of encouraging researchers and educators in computer vision to contribute to an on-line computer vision education repository. The impetus for developing this resource came from the 2000 Workshop on Undergraduate Education and Image Computation held in conjunction with The IEEE Conference on Computer Vision and Pattern Recognition [CVPR].

Participants from a number of institutions commented on the difficulty of obtaining high-quality image data sets for assignments. The cost of high-quality cameras, calibrated imaging equipment, and stereo cameras, in particular, precludes many institutions from doing effective laboratory assignments on modern computer vision [CV] topics.

A survey of computer vision education also indicates that generating a high-quality CV laboratory experience for undergraduates is a challenging task [2]. Because of the open-ended and complex nature of many CV topics, it is not uncommon for an assignment that seems like a great idea up front to turn into a nightmare assignment for students that leaves them feeling frustrated more than educated. Clearly, it is important

to have assignments that give students a feeling of accomplishment. Despite our best intentions, however, conflicting demands on our time mean it is not always possible to thoroughly vet an assignment in advance, which can result in a difficult experience for both the teacher and the student. The resources we hope to make available will include a variety of vetted assignments of varying difficulty, complete with solutions that we will make available to CV educators.

This kind of a centralized resource also creates a pathway for current research efforts to be disseminated in an educational context. None of us are experts in all areas of computer vision, but most a computer vision courses include a broad array of topics. Arguably, educators develop better educational exercises in their areas of personal expertise. Having a centralized resource gives educators access to educational materials developed by people with a variety of expertise.

2 Resource specification

The current plan is for the on-line CV education resource to contain the following components.

1. A set of CV assignments ordered by topic and difficulty. If possible, each assignment will contain instructions and all necessary images to complete it. CV educators will be able to get solutions for each assignment upon request. Each assignment's home page will include links to and forms for reviews from previous users, both educators and students.
2. A set of CV homework assignments: short exercises that may include short programming or simulation exercises. Solutions will be available to educators on request.
3. A listing of available textbooks, publishers, and textbook web-sites, comparative book reviews by the author--see, for example, [2]--and reviews from other CV educators.
4. An annotated listing of CV software packages, both commercial and open-source, along with reviews from educational users. Links to these packages, and to institutions that use them for CV education will also be included.

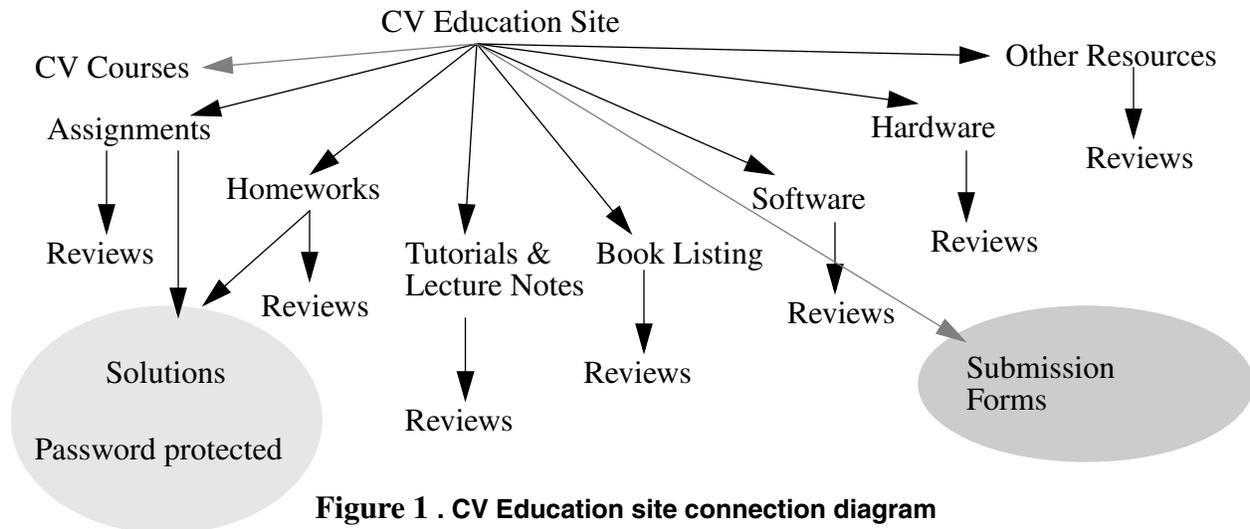


Figure 1 . CV Education site connection diagram

5. Links and information about CV hardware, such as how to setup a camera and framegrabber on a Linux workstation for less than \$200.
6. Links to the home pages of CV courses at institutions around the world.
7. Lectures notes from CV educators, including the author's Computer Vision lectures notes.
8. Links to other CV on-line resources, such as the CMU Computer Vision Home Pages and the USC Vision Bibliography.

The on-line resource may eventually contain other educational resources, depending upon the response from the CV education community. Note that an essential part of this resource will be forms that enable users to register reviews and suggestions about the materials it contains. The site will also have a method for submitting new material.

3 Organizing and vetting the resources

The web site will be organized as a short hierarchy for quick browsing by educators. Figure 1 shows the planned site organization. Certain sections of the site--for example, assignment and homework solutions--will be password protected.

Lab assignments and homeworks placed on the CV Education site will be vetted through a multi-step process

1. The first step is to collect and organize the materials provided by the contributor.
2. The second step is to test the assignment instructions by having both the author and one or more undergraduates follow them. We will note instructions that are unclear or incomplete and modify them as appropriate.
3. In parallel with step #2, we will ensure that all the materials necessary to complete the assignment exist. We will generate images or link to code libraries as

necessary.

4. If a contributor provides one or more solutions to the assignment, we will test them for correctness and clarity. We will also comment the solutions, as appropriate, so they are straightforward for other educators to follow. If the contributor does not provide a solution, we will develop one. However, we will give priority to assignments with solutions.
5. If a solution requires a proprietary library, then if time permits, we will develop a solution that uses a public domain or self-generated library in order to make the solution more generally available to educators. We will give priority to assignments with solutions that do not require proprietary software in order to maximize our efficiency.
6. Finally, we will classify an assignment and solution both according to topic and the type of solutions: A) C/C++ with standard or public domain libraries, B) other programming language with standard or public domain libraries, C) C/C++ with proprietary libraries, D) other language with proprietary libraries, and E) commercial solutions, such as Matlab. These classifications will permit educators to select assignments that are appropriate for their existing resources.

Note that it is quite possible that, over the course of vetting the assignments, we develop a standard library of routines in C/C++ or a package like Matlab that are applicable to a number of the assignments. Such a library will be made available to CV educators as part of the site. We may also decide to use an existing public domain code library and as the basis for our solutions.

4 Intellectual Property

On the CV Education site there will be a significant

amount of intellectual property from a variety of people, and potentially institutions. Because of this, we need a clearly stated policy for handling intellectual property that will both encourage contributions to the site and maintain the integrity and availability of the resource to all educators.

The IP policy will incorporate the following principles:

1) As much material as possible should be available to CV educators at minimal, if any, cost (for example, the cost of burning and shipping a CD if someone requests a hard copy).

2) The IP rights of contributors should be maintained to the fullest extent that is reasonable

3) IP rights will be different for different kinds of contributions, largely according to the level of effort required to develop a particular type of contribution

Example I: lectures notes, as they probably require the greatest amount of effort, will be clearly marked as the copyright of the developer. The site will make this copyright notice explicit, and the contributor can ask us to remove, update, or modify the contribution at any time. In many cases, this kind of contribution will likely be a link to a web page maintained by the contributor so that they have complete control over their own intellectual property.

Example II: Reviews and suggestions submitted to the web site regarding materials posted on or linked to the site should be considered to be placed in the public domain. This is information that should be freely available to all parties as it informs educators about the quality and usability of the educational materials linked together on the CV Education site.

Example III: Ideally, textbook and software package reviews--i.e. reviews about materials not contained on the CV education site--should also be considered public domain. However, in this case there may be conflicting copyright demands since textbook and software package reviews may also be published in academic journals (see [2] or [3], for example). In the case of conflicting copyright claims, the materials will be posted on or linked to the CV education site according to the rules that apply to the published materials. For example, some journals or professional societies permit authors to post electronic versions of their papers on-line with certain restrictions or required copyright notices [1].

Example IV: Software packages contributed to the CV education site will be the intellectual property of the contributor and the policies for distribution and modification will be specified by the contributor. As in the case of lecture notes, unless otherwise desired by the contributor, posting this material will likely consist of linking the CV education site to a site maintained by the developer in order to ensure the integrity of the contribution.

Example V: Assignments, image data sets, and solutions are the trickiest intellectual property to handle. In the case of assignments linked to the site, but maintained by a

contributor, the intellectual property is clearly that of the contributor and we will state this on the CV education site.

In the case of vetted assignments that are maintained and updated by the author and students, the solutions, data sets, and assignments may be the result of collaborative efforts involving different levels of contribution from multiple individuals. In the case of collaborative efforts, there are a couple of possible solutions.

First, all parties could agree to turn over the intellectual property to an institution, such as Swarthmore College, which would commit to maintaining and distributing the information. The original contributor would be guaranteed access and usage of the material in perpetuity. Swarthmore, as an institution dedicated to undergraduate education would be responsible for handling all intellectual property queries and requests, and would be responsible for distributing any profits that might result from a future arrangement--such as a request from a publisher to include the assignment in a textbook. Possibilities for distribution of proceeds include: 1) using some or all of the funds to maintain and update the CV Education site, or 2) returning some or all of the funds to the contributors according to a formula. The procedure for this option would be for the parties to agree to the general outline and formula specifics at the time the material is contributed to the site.

A second possible solution is to have the parties agree to apply something like the GNU General Public License to the intellectual property associated with the assignment. This would guarantee that it would always be freely available to all educators. It also eliminates the possibility of any monetary benefit, so that issue is not a factor.

In either case, it is important to ensure that the original contributor retains sufficient rights, and or rewards, so they are willing to contribute the material to the site for distribution. It is likely that different contributors will have different priorities with regards to intellectual property. Therefore, we will offer at least these two options for the intellectual property contained in assignments, data sets, and solutions to all contributors and let them choose the option with which they are most comfortable. If a contributor wishes to retain all rights, then we will ask them to maintain the assignment themselves, and we will place a link to it on the CV education site.

5 How can you help?

The key purpose of this paper is to recruit contributors to the CV education site. There are many ways to contribute, at many levels of commitment.

1. Fill out a survey about your computer vision course and let us put a link to it on our site. You can find the survey at <http://www.palantir.swarthmore.edu/~maxwell/visionCourses.htm>.
2. Use the materials that will be appearing there over the

next six months. Then link the site to your course home page and provide feedback to us about how well the materials worked.

3. Contribute reviews (short or long) of software and textbooks you have used.
4. Contribute an image data set, or an assignment or two to the web site.

We will also gladly accept suggestions about organization and materials for the site. If we have left anything out that you feel would enhance its usability for educators, please let us know at maxwell@swarthmore.edu.

References

- [1] IEEE Policies and Procedures: Electronic Information Dissemination, <http://www.ieee.org/about/documentation/copyright/policies.htm>, June 2001.
- [2] B. A. Maxwell, "A survey of computer vision education and text resources", in Proceedings of IEEE Workshop on Undergraduate Education and Image Computation, June, 2000 (to appear in *Int'l Journal of Pattern Recognition and Artificial Intelligence*, 2001).
- [3] B. A. Maxwell, "Teaching computer vision to computer scientists: issues and a comparative textbook review," in *Int'l Journal of Pattern Recognition and Artificial Intelligence*, Vol. 12, No. 8, pp. 1035-1051, August 1998. Versions of this paper are also included in *Proceedings of SPIE Medical Imaging '98* (February 1998) and the *Proceedings of IEEE Workshop on Undergraduate Education and Image Computation* (June 1997).