Int. J. Engng Ed. Vol. 26, No. 6, pp. 1445–1454, 2010
Printed in Great Britain.

0949-149X/91 $3.00+0.00

Linking Research and Teaching through an Applied Computer Vision Course*

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In this paper we present our experience of designing a course shared between the European Erasmus Mundus Master's Degree in Computer Vision and Robotics (VIBOT), and the local Master's Degree in Industrial Computer Science and Automation, both of which are official qualifications at our university. The main aim of the course is to integrate a number of different subjects, such as computer vision, computer programming, perception systems, databases and computer engineering, by using an open research platform called PASCAL. We aim to demonstrate the effectiveness of such a practical course that integrates technology and research into educational methods. We describe this integration, by presenting and evaluating the methods used and identifying the links between research and teaching techniques. As a practical approach, the majority of educational activities are developed in our university labs, where we work with students from all five continents, mixing national and foreign students into different workgroups. The students are greatly motivated by working in such an environment and on this research platform, which permits them to consolidate their existing knowledge and extend their curricula.

Keywords: course design; computer vision; integrating research and teaching

1. INTRODUCTION

FOR ENGINEERING and science professors, enhancing students' understanding of scientific concepts and process skills rather than merely teaching lower, textual-level scientific knowledge is a major goal [1]. Some promising steps in this direction have already been successfully implemented, such as integrating computer-based learning environments to promote student learning and attain this goal [2,3]. Some authors have proposed an experimental platform as an innovative educational tool to integrate different interdisciplinary curriculum knowledge [4]. The potential benefits of these innovations include greater mastery of scientific concepts and the development of positive student attitudes towards engineering and science. For example, an Information and Communication Technology (ICT) learning environment provides university students with swift access to new information. Applied correctly, it can make instruction more diversified, flexible, and effective [5]. In several cases it has effectively raised the students' critical thinking level [6] and facilitated problem-solving [7], and offers learning tools that can develop related scientific abilities [8]. Other researchers have suggested that the real value of ICT might lie in its different transformations among representations [9]. It is also the case that learning environments using computer-based technologies promote constructive learning that enhances student problem-solving abilities [10] and allows better learning performance [11–13].

In this paper we present the design of a course shared between the international European Erasmus Mundus Master's Degree in Computer Vision and Robotics (VIBOT) [14], and our own Master's Degree in Industrial Computer Science and Automation, both of which are official qualifications at the University of Girona (Spain). The Degrees are based on the European Credit Transfer and Accumulation System (ECTS) taken from the Bologna model [15]. The purpose of this paper is to describe the effectiveness of an applied computer vision course (entitled SSI: Scene Segmentation and Interpretation) that integrates computer-based technology and a research platform to the educational methods. We explore the effects of such integration by presenting, evaluating and discussing the methodologies used and the links between research and teaching techniques. Since we are mixing national and foreign students coming from all five continents, we also analyze the achievements and attitudes of these students toward this multicultural and international course.

The following sections describe the educational context of the course, as well as the number of credits, the participants and the contents. We also present a detailed description of our aims in planning the course and the different activities carried out and the methodologies used. We provide some helpful approaches to incorporate computer-based teaching, programming challenges, and methods, to link research and teaching to facilitate student's understanding. For instance, following some of the strategies proposed by Turns et al. [16], we have designed a set of practical sessions and a mini-project where students have to complete a research project and compare their

* Accepted 2nd August 2010

results to current published research results. We refer to this experimental platform as the PASCAL platform. The design and the technology of this platform have been extracted from a recent image classification competition known as the PASCAL Challenge [17], in which various international research groups participate every year. The goal of this research challenge is to recognize objects such as bicycle, car, motorbike, cow, or person in realistic images, thereby providing a public research benchmark for computer vision algorithms. All the subjects covered during our course are integrated in this research platform, including programming tools and images, which makes it the perfect platform for students to test the concepts they have learned. The platform also integrates different interdisciplinary subjects such as computer programming, databases and computer software engineering.

In order to analyze and discuss students and teacher satisfaction with the course, we show the academic results for the 2006–07, 2007–2008 and 2008–09 academic years. In general, from the data analyzed thus far, the results have been very positive. Proof of this can be found in both the questionnaires completed by students and their academic results. It appears that integrating new programming frameworks and technology closely related to research, as the PASCAL platform does, produces a more lively and active class, and increases student interest in the topics.

2. THE EDUCATIONAL FRAMEWORK

2.1 Context in the ECTS Bologna model

In June 1999, 29 European Ministers of Education signed the Bologna Declaration with the goal of developing a European university system and increasing the competitiveness of Europe's educational position [18, 15]. As of the fall of 2006, most of the faculties of the University of Girona had started new Master's Degree programs according to the Bologna model. ECTS is a student-centered system based on the student workload required to achieve the objectives of a program, which are preferably specified in terms of the learning outcomes and competencies to be acquired. ECTS is based on the principle that 60 credits measure the workload of a full-time student during one academic year. The student workload of a full-time study program in Europe amounts in most cases to around 1500–1800 hours per year, meaning that one credit represents around 25 to 30 student working hours.

The SSI Master's course studied in this paper was designed to have 6 ECTS credits and contain a total of 156 hours: 30 hours of face-to-face teaching, addressing theory and problem-solving; 20 hours of practical exercises; 8 hours of seminars taught by guest lecturers; and 98 hours allocated to student work, including theoretical activities and lab practice sessions all integrated within the PASCAL platform. The main contents of the SSI course are: 1) fundamentals of image processing; 2) image segmentation; 3) image characterization; 4) image classification; and 5) object and scene description. Section 3 provides more details about these topics and all the activities and methodologies proposed within the course structure.

The SSI course has been formulated in accordance with the principles of the European Higher Education Area (EHEA), which include creating more comparable, compatible and coherent systems of higher education in Europe—the objective of the Bologna process. The design and plan of activities for each subject can be found on the University of Girona's own website '*La meva UdG*' [19]. Students have access to the departmental intranet, where all course subjects are formulated using the same tools (i.e. Moodle). Among other resources, there is a calendar and course schedule, access to the virtual learning platform '*Plataforma e-learning ACME*' [20] and a forum.

2.2 Academic program

The European VIBOT Master's Degree is organized by a European consortium of three universities: the University of Bourgogne (France), the University of Girona (Spain) and the Heriot-Watt University (UK). This Master's Degree responds to current needs in industry; its two main scientific areas of study are computer vision and robotics. The academic program of the European VIBOT Master's Degree comprises two years, divided into four semesters. The first three semesters take the form of face-to-face classes while the final semester consists of researching and writing a Master's thesis at one of the aforementioned universities or at another university or company that has a cooperation agreement with the consortium. The language used throughout the two years of the program is English.

The Master's Degree in Industrial Computer Science and Automation [21] is also an official qualification at our university, but almost all the students are Spanish nationals and therefore their native language is not English. The academic program for this Degree also comprises two years divided into four semesters with the final semester being dedicated to produce a Master's thesis. It is important to mention that both Master's Degrees are based on the ECTS model [18, 15], a crucial factor to take into account in the design of the course. We have participated in the design and development of the teaching plan for this computer vision course from the very beginning, when the Erasmus Mundus proposal was first made and presented to the EU, to its current implementation. At the time we were under the growing influence of the EHEA and the principles of good teaching practice that had been discussed in several works [22–26]. Moreover, we were all involved in the BSc Degree in Computer Management Engineering, BSc Degree in Computer Systems Engineering, and MSc Degree in Computer Engineering at our university, which were then being transformed and adapted to the EHEA.

2.3 Participants: students for the 2006–07, 2007–08 and 2008–09 academic years

Let us introduce here the multicultural and international nature of the participants in the SSI course. During the 2006–07 academic year a total of 24 students enrolled on the European VIBOT Master's Degree, while seven Spanish students enrolled on the local Master's Degree. It is worth highlighting that 21 of the 24 students who enrolled on the European Master's Degree came from outside Europe, from countries as far apart as Indonesia, Pakistan, Mexico, China, Vietnam, Costa Rica, Iran, New Zealand, India and Colombia. Of the other students, one was from France and two from Italy.

During the 2007–08 academic year there were a total of 33 students on the VIBOT Master's Degree, from India, China, Malaysia, Pakistan, Iran, Ukraine, Brazil, Mexico, Costa Rica, Egypt, and Kenya. Eight students came from European countries. Moreover, seven Spanish students joined the local Master's Degree. Finally, during the 2008–09 academic year we had a total of 22 students for the VIBOT Master's Degree, coming from Brazil, USA, Costa Rica, Pakistan, Iran, Singapore, Indonesia, Uzbekistan, Bangladesh, Ethiopia and Sudan, and including four from Europe. Two Spanish students enrolled again on the local Master's Degree.

It is important to point out that students on the European Master's Degree receive a full grant from the EU. Therefore, very stringent enrolment requirements are demanded of them: 1) 180 ECTS credits, a minimum grade equivalent to a European standard grade B (for example: 7/10 in Spain, 14/20 in France and 2.1 in the UK), and 2) an adequate level of English for the course, corresponding to a TOEFL score of 550, an IELTS score of 6.5 or Grade C in the Cambridge Proficiency in English exam. Approximately 120, 185, and 170 applications were received for the 2006–07, 2007–08 and 2008–09 academic years respectively. These data regarding the backgrounds of students on the European Master's, and also the fact that Spanish students enrolled on the local Master's study the same subject, show the need there was to design a course for such a culturally and linguistically diverse group.

Regarding student curricula and academic background, our course is aimed mainly at engineering students. It is recommended that students have previously acquired basic skills in fundamental areas such as computer programming, perception systems, and computer software engineering.

2.4 Definition of skills

In terms of definitions, generic skills were defined on the basis of the Spanish Computer Engineering white paper cited in the bibliography [27] and other documents from the European consortium, and the Master's Degree coordinators assigned skills to the subjects. On the basis of this first proposal, meetings were held with professors in charge to establish the skills to be developed for the subjects. Each subject description had a special section labeled 'Other skills', which each professor could use to provide a more detailed description of skills to be learned. Specifically, in our subject we work on specific skills related to the subject matter, plus transversal skills that we define as the main means of learning the specific skills. Here we are basically referring to three types of skill: 1) working within a multicultural and multilingual group (this skill entails the management and coordination of the workgroup, leadership, organizational and planning skills, competitiveness, quality research, etc.); 2) the use of English as a common and sole language of communication; and 3) working towards improving both written and oral communication skills.

3. THE EDUCATIONAL PROGRAM: LINKING RESEARCH AND TEACHING

As mentioned in the previous section, the SSI course is mainly for master's degree students with an engineering background and who also have some basic skills in fundamental areas such as computer programming and computer engineering. A self-guided practical lab manual that includes a theoretical introduction to these related issues is provided for students coming from different educational backgrounds with different curricula. In this way, these students can follow the course without any difficulty. Furthermore, the three teachers on the course provide adequate assistance for students to acquire different levels of skills, according to their educational background, through a continuous assessment process.

The SSI course contains theoretical and laboratory sessions, related to the following computer vision topics [28, 29]:

- *Fundamentals of image processing*. This block briefly reviews the fundamentals of image processing. Several of these basic concepts (i.e. pre-processing steps such as noise reduction, edge detection, morphological operations, etc) are needed in the design of high level processes.
- *Image segmentation*. In this block we introduce the concept of image segmentation, which refers to the process of partitioning a digital image into multiple regions (group of pixels that share certain visual characteristics). Several image segmentation techniques (i.e. region growing, k-means, graph cuts, mean-shift, etc.) are studied and discussed during the course.
- *Image characterization*. This block describes different techniques that allow relevant information to be extracted from images in order to perform a later task, such as object recognition

or scene description. Color, texture, and shape features are studied. More recent features based on the detection of interest points in the images (i.e., SIFT [30] and SURF [31] features) are also explained during the course.

- *Image classification*. We introduce the concept of image classification in this block. Classification is the procedure by which individual items are placed in groups based on quantitative information about one or more characteristics inherent in the images, and is usually based on a training set of previously labeled items. A large number of classifiers are described and used in the SSI course [28, 29] (i.e. K-Nearest Neighbors, linear classifiers, SVM, Adaboost, etc).
- *Scene description.* The last block of the course presents different strategies to perform object recognition and scene description, focusing on new trends that use visual vocabularies [32]. All the previous blocks are used here to develop a complete classification system that is able to recognize objects in images.

As well as all these topics related to computer vision, our course integrates different interdisciplinary subjects such as:

- *Computer programming*. This concerns the process of writing, testing, debugging/troubleshooting, and maintaining the source code of computer programs. In our course, students use the MATLAB© software environment of MathWorks [33] to develop their code.
- *Databases*. This block concerns to the management of databases (i.e. creation, maintenance, and use of database storage structures). In particular, students on the SSI course deal with an image database that includes original images, manual segmentations, and object annotations.
- *Data mining*. Data mining studies the processes of extracting patterns from data. Data mining techniques have become increasingly important tools to transform data into information, being widely used in many computer vision areas such as pattern recognition and classification.
- *Software engineering*. In order to develop an object recognition system, students need to apply a systematic strategy of development and maintenance of their code. This means applying engineering to software and implies designing, implementing, and improving software that is of a higher quality, more maintainable, and quicker to build.

The integration of these interdisciplinary subjects is achieved through the PASCAL platform, where our students develop all their practical work. This platform was developed within a European research project with the idea of promoting an image classification competition known as the PASCAL Challenge [17], in which research groups from universities all around the world participate every year. The goal of this research challenge is to recognize objects from a number of visual object classes in realistic scenes, a topic widely investigated nowadays by the computer vision research community. The PASCAL challenge contains twenty object classes classified into four categories: *Person* (person); *animal* (bird, cat, cow, dog, horse, sheep); *vehicle* (airplane, bicycle, boat, bus, car, motorbike, train); and *indoor* (bottle, chair, dining table, potted plant, sofa, tv/monitor). The database contains a total of 14743 annotated images. In the real competition, the data is released in two phases: 1) annotated training and validation data (ground-truth) is released with the development kit; 2) unannotated testing data is released at a later date. This testing data is used to obtain the performances of all the approaches of the different research groups participating in the challenge. Note that a quantitative evaluation of different strategies is possible since annotations are available. For instance, when dealing with the segmentation problem, manual segmentations included in the PASCAL platform allow to analyze the algorithms performance using quantitative evaluations.

The PASCAL Challenge consists of three main competitions (tasks):

1. *Classification*: For each of the object classes, predict the presence/absence of an example of that class in the test image. Figure 1 shows different examples of images used to perform the image classification. Observe that these images contain object classes under different conditions (such as changes in scale, orientation, perspective, illumination, etc).
2. *Detection*: For each of the classes, predict the bounding boxes of each object of that class in a test image (if any). Figure 1 shows some examples of bounding boxes identifying the objects detected.
3. *Segmentation*: For each pixel in a test image, predict the class of the object containing that pixel or background if the pixel does not belong to one of the twenty specified classes. Figure 2 shows two examples of objects with their corresponding pixel segmentation (these are the annotations (manual segmentations) used to evaluate the performance of the different algorithms).

In order to adjust the difficulty of the PASCAL challenge to our master's course, we reduced it to meet our needs, adapting the development kit provided for the competition (MATLAB code) and reducing the total number of images, annotations, etc, thereby creating our own PASCAL platform. For example, all the images from the original database labeled as difficult were removed from the PASCAL platform. Moreover, we decided to include only 10 different object classes (these objects are the ones shown in Fig. 1). There was a total of 1060 images included in our platform, with 1900 different object appearances. Notice again that the PASCAL platform covers the main subjects of the SSI course, so it is the

Fig. 1. Classification PASCAL Challenge. Image examples for ten different object classes. Note that this object classification problem is not trivial due to changes in scale, rotation, perspective, etc. Many research groups are now using this PASCAL challenge as a benchmark for evaluating their research.

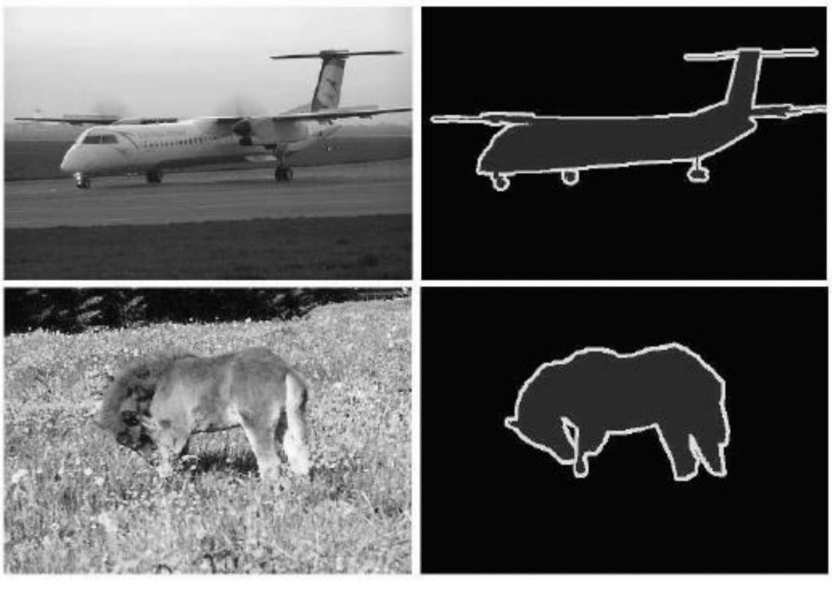

Fig. 2. Segmentation PASCAL Challenge. Two different image segmentation examples with the corresponding manual annotations.

perfect platform for students to test the subjects they have learned. In particular, we included in our PASCAL platform two of the previously described challenges: segmentation and classification.

Next we will explain the different methodologies and activities we designed for the SSI course, and also describe all the links with the PASCAL platform. We include different activities, whose design was based on the following learning techniques:

- Activities in which the students must teach and/or explain a specific subject area to other students.
- Activities in which students must apply the knowledge they are learning.
- Activities in which there is group discussion.

We basically use two types of activities: 1) those based on students' lab practice, where they apply the knowledge they have learned, and 2) activities in which students must learn a new subject area and then prepare themselves to teach it to other students, leading to group discussion. However, theory and problem-solving classes, as well as seminars by guest professors, are also included.

With regard to the organization of group work, all lab practice activities are designed as activities that can be carried out in pairs. That is, students choose a 'lab mate' with whom they do all their lab practice during the course. We decided to use a different strategy for the activity in which students were to teach (lecture activity). Here we incorporated the intercultural element of the group and formed workgroups randomly, with the result that students on the European and local Master's Degrees carried out activities together.

The aim of mixing students together is very clear: to promote social and personal skills, flexibility in methods, language qualifications, to learn to work in a team, and to interact effectively in a multicultural and multilingual environment. These are key fundamental skills, the demand for which has increased in the global labor market, alongside the value placed on students' technical knowledge. In addition, the students' growing demands to be more involved in their own education is also catered to through the different techniques used on the course.

3.1 Block 1. Lab practice sessions

The lab practice block was divided into two very different parts. The first part includes two relatively short activities that we refer to here as P1 and P2. These are two lab sessions of two hours each, led by professors, which serve to introduce the MATLAB development tool and liven up the first practical sessions to help students gain confidence. In these sessions the students have to understand a given problem and then analyze, design and code algorithms in MATLAB. These algorithms are then tested on the PASCAL platform. In terms of content, the first lab activity (P1) is related to the image segmentation problem, while the second one (P2) deals with image characterization, focusing on the texture feature extraction problem. Notice that the PASCAL platform also provides tools to perform an evaluation of the results. For instance, when dealing with the segmentation problem, the manual segmentations available in the PASCAL platform can be used to obtain quantitative evaluations, from which the students can compare their algorithms performance.

In the second part of this block, a mini-project is designed where students, also in pairs, have to complete a research project of more substance. For this, which we refer to as the PASCAL project, students have eight weeks to develop a complete image classification system. As already mentioned, the design and the technology of the mini-project is directly extracted from the PASCAL Challenge [17]. As in the classification competition, the main goal of the mini-project is to recognize objects such as bicycle, car, motorbike, cat, cow, dog, or person in realistic images. This image classification problem is a difficult task, especially due to the fact that one object could appear blurred, with a high level of occlusion, rotated, or at a different scale, in a small image area. These are typical issues investigated within the computer vision community, and in our mini-project students have to analyze and design their own strategies to deal with them. We also decided to incorporate an element of competition between our students in the final group discussions of the different approaches, results, and implications for the classroom.

In terms of assessment for the first two practice components, P1 and P2, 70% of the mark is awarded for the strategy used and results obtained, and the remaining 30% for the document produced by the students. Similarly, for the PASCAL project, 70% of the mark is awarded for the strategy used and results obtained, and 30% for the document detailing and analyzing the project. During these lab sessions the role of the professor is to guide the students through the technical aspects as well as the formal part: planning the work, giving advice, and helping them with the documentation and oral presentation.

3.2 Block 2. Lecture activity

We propose another activity to link research and teaching. In this case, students learn a new subject based on information extracted from research papers (mostly strategies of participants in previous PASCAL challenges) and then prepare to teach it to other students. From this activity we expect an academic presentation (oral and written) on a specific subject area and a large number of skills are developed while achieving this objective. In brief, it requires an initial stage for researching and analyzing existing information. An additional stage is then required for gathering and assimilating the information. During this stage students interact with professors (individual group tutorials) to review the work conducted thus far. Advice is also given about tools for managing and planning this work. Finally, students prepare the written document and the oral presentation. At the end of the activity (after the class has been taught and students have discussed the subjects in the classroom) the professors issue, in addition to the list of marks, reports highlighting the strengths and weaknesses of the work conducted and recommending improvements.

Different working subject areas are proposed for this activity. As with the groups, they are chosen randomly. Two different groups work on the same subject so it is therefore possible to give different focuses and ensure that information is better complemented. Students have four weeks to complete the project. Note also that here we randomly mix students from the VIBOT and local Master's Degrees, which forces them to interact, promotes their social, personal and language skills, and teaches them to work in teams.

The marks for these lecture activities are awarded in the following way: 50% are awarded for the explanatory document (which can be considered as notes for other students), and the other 50% for the presentation (production of slides plus a 20-minute oral presentation). Student interaction and group discussion is also taken into account. As previously mentioned, each subject is prepared by two different groups, and each of the groups has to prepare a few questions for the other group presenting the same subject area.

Final SSI course assessment is obtained in the following way: 30% is awarded for the first two lab practice activities, P1 and P2, 40% for the PASCAL mini-project, and finally 30% for the lecture activity (classes prepared and taught by students).

3.3 The role of the professor

The role of professors in the aforementioned activities also deserves comment. In both theory-based and problem-solving activities, as well as in lab practice, the professors assume the role of tutor and guide. This means that, as well as ensuring that tasks are being carried out satisfactorily, they must assume the role of guide and positively influence the students' learning process. To this end, it is also imperative that professors collaborate and interact with students. As we have mentioned in the comments regarding Block 2, each group completes various tutorials to review, supervise and guide the work conducted during the activities. The professors must also assume this role for lab practice activities, and for students' mini-projects. It is important to provide students with fast and useful feedback, indentifying the strengths and weaknesses of their work.

4. RESULTS AND DISCUSSIONS

In this section of the article we present the academic results obtained for the 2006–07, 2007–08, and 2008–09 academic years, and analyze the students' and professors' satisfaction with the course. In general, from the data analyzed thus far, we can draw positive conclusions from the academic results with regard to the ECTS adaptation of the course. It should be highlighted that the 2006–2007 academic year was the first in which the local Master's Degree course was integrated with the new European Master's Degree. Despite this, we would like to repeat that there is enough evidence to convince us that uniting all students on the two Master's Degrees, and having them work together, has positive effects. In particular, we have detected higher levels of motivation in the local Master's Degree students. It seems that the integration of new programming frameworks and recent and innovative computer-based technology, such as that used in the PASCAL platform, produces a more lively and active science and technology class.

Table 1. Academic results obtained in the academic 2006–07, 2007–08 and 2008–09. Grade A is between 9 and 10, Grade C is between 5 and 7, Grade B is between C and A, while Grade D is less than 5.

Academic year	Assessment	Percentage	Number of students
2006–07	Grade A	42%	13
	Grade B	52%	16
	Grade C	6%	2
2007–08	Grade A	27%	11
	Grade B	73%	29
2008–09	Grade A	46%	11
	Grade B	50%	12
	Grade C	4%	1

We have also observed that mixing students (in random groups) for activities has helped them to develop their social, personal and language skills, and to interact effectively in a multicultural environment.

Designing this course has clearly helped us to reflect on our own teaching and generally improve this aspect of our work, but this does not automatically lead to direct improvements in academic results. There are certainly other factors that affect academic performance, such as students' basic preparation, the country of origin of students on the European Master's course, the synergy that may be created in the group of students on both the European and local Master's courses, etc. However, we are convinced that all these factors have made a positive contribution to the results of the groups for these academic years, as can be seen in Table 1.

4.1 Evaluation of results

In order to evaluate students' degree of satisfaction with the course, we carried out a survey using a questionnaire and analysed the results. Table 2 shows an example of the questionnaire form. In general, the students expressed their satisfaction with the activities conducted on the course, such as, for example, practical work with the PASCAL platform, the lecture activity and the tutorials conducted to monitor work undertaken. Table 2 details the students' response and the overall evaluation for the 2008–09 academic year. Note that students evaluated the course very positively. The average scores of these questionnaires were 3.95, 4.11, and 4.25 for the academic years 2006–07, 2007–08, and 2008–09 respectively with 5 being the highest possible score. We would like to point out that, within the framework of the Master's Degrees and the six different subjects taught at the University of Girona, ours is the one with the highest marks based on questionnaires.

In line with the other courses, the overall results of the questionnaires for the Master's Degree are very encouraging. High scores are obtained for the learning activities and tutorial support (4.20),

Table 2. Questionnaire given to the students. Scores from 1 to 5 (5=highest). The results shown here are the averages of all the students from the 2008–09 academic year

Questionnaire	Score
Learning	
Did the module give you confidence to apply theory?	4.11
Did the module give you confidence to apply practice?	4.00
Do you feel you have acquired deep understanding of the subject?	3.88
Linking with previous modules	
How well did the previous modules provide essential background knowledge?	4.25
Module content	
Did you find the module content satisfactory in terms of theory?	4.33
Did you find the module content satisfactory in terms of practical work?	4.28
Was the module interesting?	4.56
Organization	
Was the course organization (deadline, objectives, . . .) explained to you and followed?	4.50
Were the lectures well organized?	4.44
Were the labs well organized?	4.28
Were the project/others activities well organized?	4.39
Delivery	
Did you find the course was delivered at the appropriate speed?	4.24
Did you find the lecturer was able to communicate his/her ideas appropriately?	4.33
Was the lecturer helpful?	4.47
How timely was the feedback?	3.89
How good was the interaction with the lecturer?	4.41
Labs/Tutorials/Coursework	
Did you find the lab useful?	4.50
Did you find the tutorial useful?	4.38
Did you find the coursework useful?	4.56
Equipments	
Did you find the laboratory equipment satisfactory?	4.19
Did you find the computer equipment satisfactory?	4.00
Did you find the project equipment satisfactory?	4.06
Scholarship	
Did you read related books or journal articles?	4.25
Did you write scholarly motivated essays or reports?	4.67
Did you present your work in front of an audience?	4.73
Assessment methods	
Is there a balance between the importance of a test and the amount of work required to carry it out?	4.22
Was the material presented in the module sufficient to succeed in the course?	4.00
Have you had enough information (for example tutorials . . .) to prepare the course?	4.00
Do you think the assessment method was fair?	4.30
TOTAL:	4.25

learning mechanisms and administrative support (4.06), and all modules individually. Thanks to these surveys being carried out each year, problems and improvements are spotted immediately, enabling results to be improved even further the following year.

5. CONCLUSIONS

In this study we have presented an applied computer vision course taught with computer-based technology. The course is shared between a European Erasmus Mundus Master's Degree in Computer Vision and Robotics, and a local University of Girona Master's Degree in Industrial Computer Science and Automation, both of which are official qualifications at our university. It is an innovative course that integrates a research platform into the educational methods, and requires us to design lesson plans collaboratively. We found this to be a fulfilling experience, which improved our view of collaboration and resulted in better teaching.

The activities proposed in this study enhanced the integration of theory and practice. We created more teaching ideas and modified our own methods of teaching. Moreover, the integration of new programming frameworks and the methodologies used helped the students to develop their social, personal and language skills, and to learn to work in teams.

The results for the 2006–07, 2007–08, and 2008–09 academic years are very positive. Based on student feedback, the most important characteristics are the interesting and attractive educational and practical aspects of the course. One of the suggestions is to increase the number of hours to perform the theoretical analysis, lab practices and algorithm implementations better. In addition, some students decided to do their master's thesis project on topics related to the PASCAL challenge.

The teaching experience gained from the course has proved the usefulness of the PASCAL platform for education. Activities must be designed that represent work that is appropriate for the course, and we, as professors, must be able to provide quality instruction in this area. In this respect, efforts must be made to provide students with useful feedback, one of the aspects we intend to improve on the current course.

Acknowledgments—We would like to thank all of the professors on the Master's course, and all the colleagues and students who have helped us to improve the work we do on it.

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