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EASYCOMVI: A TOOL FOR THE INTERACTIVE LEARNING OF COMPUTER VISION IN DISTANCE EDUCATION

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Abstract

This article presents the EasyComVi Tool, an interactive application developed to facilitate the study of Computer Vision for students enrolled in an Engineering Master degree with a Distance Learning methodology. The main objective of this tool is to enable students in subjects related to Computer Vision with a distance learning methodology, to acquire a better understanding of different concepts about the subject studied in a theoretical way, through its interactive visual illustration, in an autonomous way. This tool offers the students the possibility to visualize the results of applying different image processing operations to various example images selecting the value of a set of input parameters. The usefulness and applicability of the tool has been evaluated by means of a questionnaire disseminated among the students of a subject on Computer Vision in a Master's degree in Industrial Engineering. This paper presents the preliminary results obtained in the study carried out, which are very promising and encourage further research in this work.

Keywords:

Computer Vision; Image Processing; Distance learning; Interactive Tool; Assisted learning.

Introduction

For the development of applications capable of applying computer vision algorithms to solve problems of diverse nature, it is necessary to have a solid theoretical knowledge of the subject. Therefore, the theoretical study of the basic concepts of computer vision is essential to be able to tackle these problems successfully in practice. However, over time it has been observed that students enrolled in subjects related to Image Processing and Computer Vision encounter problems in translating the knowledge acquired through theoretical study of computer vision into practice.

On the one hand, although the students understand the concepts studied theoretically, they encounter problems when it comes to understanding the results obtained by applying these algorithms in practice. On the other hand, some students have difficulties when it comes to programming, which prevents them from being able to easily use the existing programming tools to check in a practical way what the result of the theoretical application of these concepts is. Therefore, there is a gap between the theoretical knowledge acquired and its understanding in practice.

The importance of Computer Vision Education was already highlighted several years ago (Bebis et al., 2003). In recent times, the education community has made efforts to make contributions to the improvement of computer vision education (Geronimo et al., 2013; Lámer et al., 2013; Reimer et al., 2011; Sigut et al., 2020; Vital et al., 2019). (Geronimo et al., 2013) presented a graduate course project on computer vision, whose aim was to detect and recognize traffic signs in video sequences. In (Lámer et al., 2013), a step by step system to teach object recognition and tracking in computer vision systems is presented, for students without any knowledge about mathematical principles for computer based object detection. (Reimer et al., 2011) present Raydiance, a tangible

interface for teaching computer vision controlled by the spatial arrangement of physical tokens. A methodology to learn computer vision using an humanoid robot is presented in (Vital et al., 2019). Some authors have worked in the development of applications to support the teaching of computer vision concepts (Sigut et al., 2020). The aim of the mobile application developed in this work is to provide support for the teaching of Computer Vision concepts to complement the theoretical lectures.

The main purpose of this work is to bridge the gap between the theoretical basis and the practical application in the learning of computer vision related concepts, overcoming the problem that the lack of a minimum programming knowledge can cause in the first instance, in a distance learning context. In order to achieve this objective, the interactive tool EasyComVi has been designed and developed, whose aim is to assist students in the autonomous study of concepts related to Computer Vision and Image Processing, learnt in a theoretical way.

The paper is divided as follows. Section 2 presents the analysis and design of the interactive tool. The development of the tool is presented in Section 3. The questionnaire developed for the evaluation is presented in Section 4, whereas Section 5 and 6 present the dissemination plan and the preliminary results obtained. Finally, conclusions are presented in Section 7.

Analysis and design of the interactive tool EasyComVi

At this first stage, the first objective has been to carry out an analysis of the basic theoretical material studied in the subject and the selection of those concepts whose learning through the study of written material is considered to be more complicated, and which we want to make easier for the students. The selected topics around which the application will be designed are two: morphological operations and basic operations between pixels.

Based on the analysis carried out, the second step was the design of the application and the establishment of the criteria that must be met in order to facilitate the learning of these concepts to the students. These criteria are detailed below:

- The application must be intuitive and easy to use.
- The application must have a separate module for each of the topics, so that it can offer personalised options depending on the topic addressed.
- The application must display on screen both, the original image and the image resulting from applying an operation.
- The application must allow the user to choose between several test images, so that he/she can observe how the result varies by applying the same operation, depending on the type of input image.
- The application must allow the user to select different operations and vary the parameters of these, observing in real time how the result varies depending on the options selected.
- In order for the student not only to better understand the concepts and operations, but also to be able to reproduce them through programming, the application must show the user how the operation he/she is currently performing could be carried out using a programming language.

Development of the EasyComVi Tool

Based on the analysis carried out and the established criteria presented in the previous section, the EasyComVi tool has been developed. This tool has been developed in Matlab (MathWorks, n.d.).

The tool is composed of two main tabs: Morphological Operations and Basic Operations between Pixels.

Figure 1 a) shows an example of how the Morphological Operations between Pixels tab looks like. In this tab, the user can choose from a drop-down menu between 5 different possible binary images. The operations that the user can execute are: dilation, erosion, opening, closing, denoising, edge extraction, hole filling and thinning (see

Figure 1 b)). In the operations that allow it, the user can choose the type of structuring element to be used to perform the operation, as well as its size (see Figure 1 c)). Finally, the tool displays the code that should be written in Matlab in order to implement the selected operation (see Figure 1 d)).

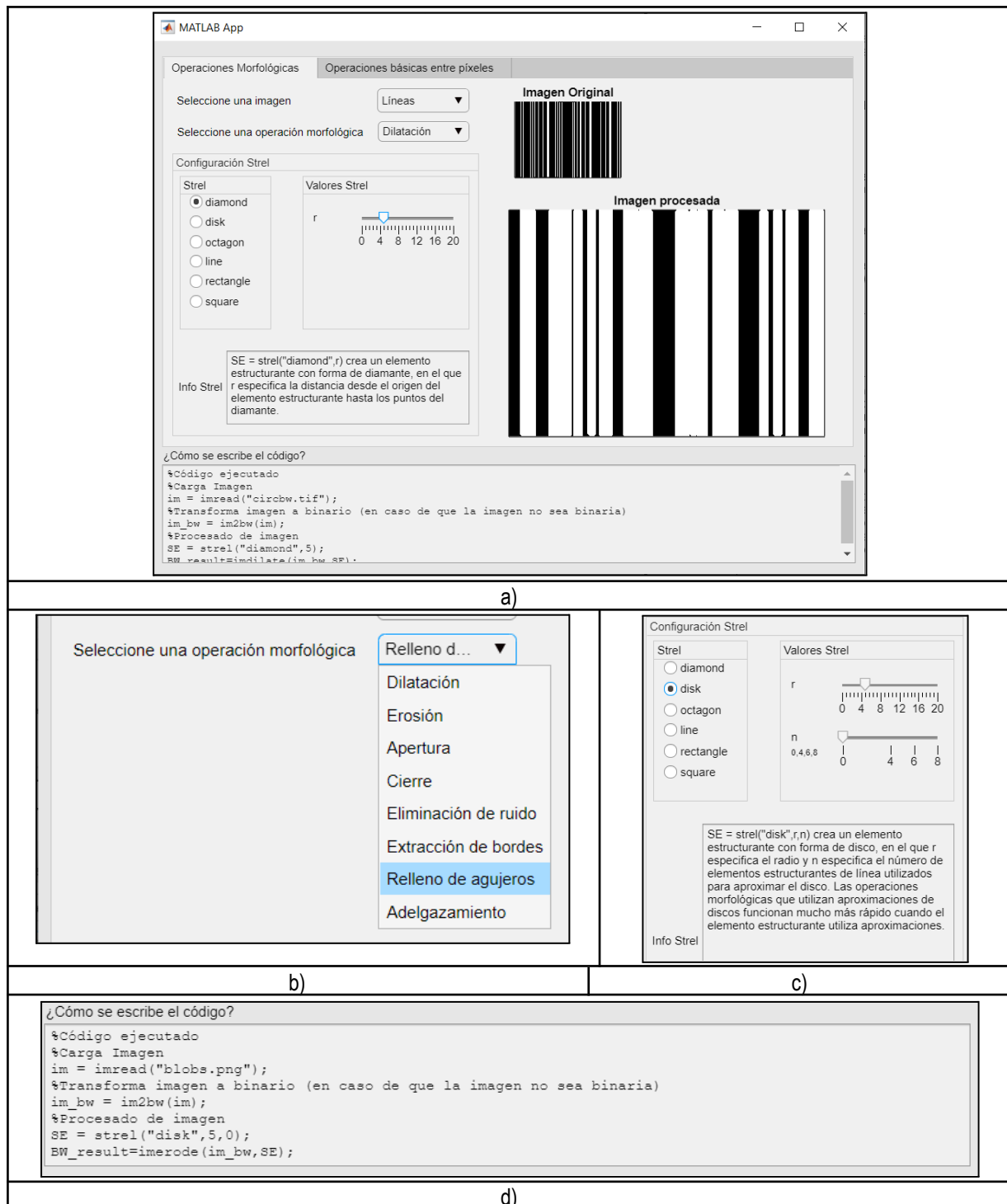


Figure 1. Morphological Operations tab in the EasyComVi application. a) Appearance of the application. b) Drop-down menu with the possible operations that can be performed. c) Example of possible configuration options that can be selected by the student. d) Example of proposed code to be implemented in Matlab automatically generated by the application.

An example of the appearance of the Basic Operations between Pixels tab is shown in Figure 2 a). In this tab, the student must select two example images, which will be used in order to carry out different basic operations. It is possible to choose among 7 different images, being possible to select the same image in both cases if desired (Figure 2 b)). The basic operations between pixels that the user can select are: A and B, A or B, not A, not B, A or (not B) and A and (not B) (Figure 2 c)). Finally, as in the Morphological Operations tab, an example of the code in Matlab that could be used in order to implement the selected operation is shown (see Figure 2 d)).

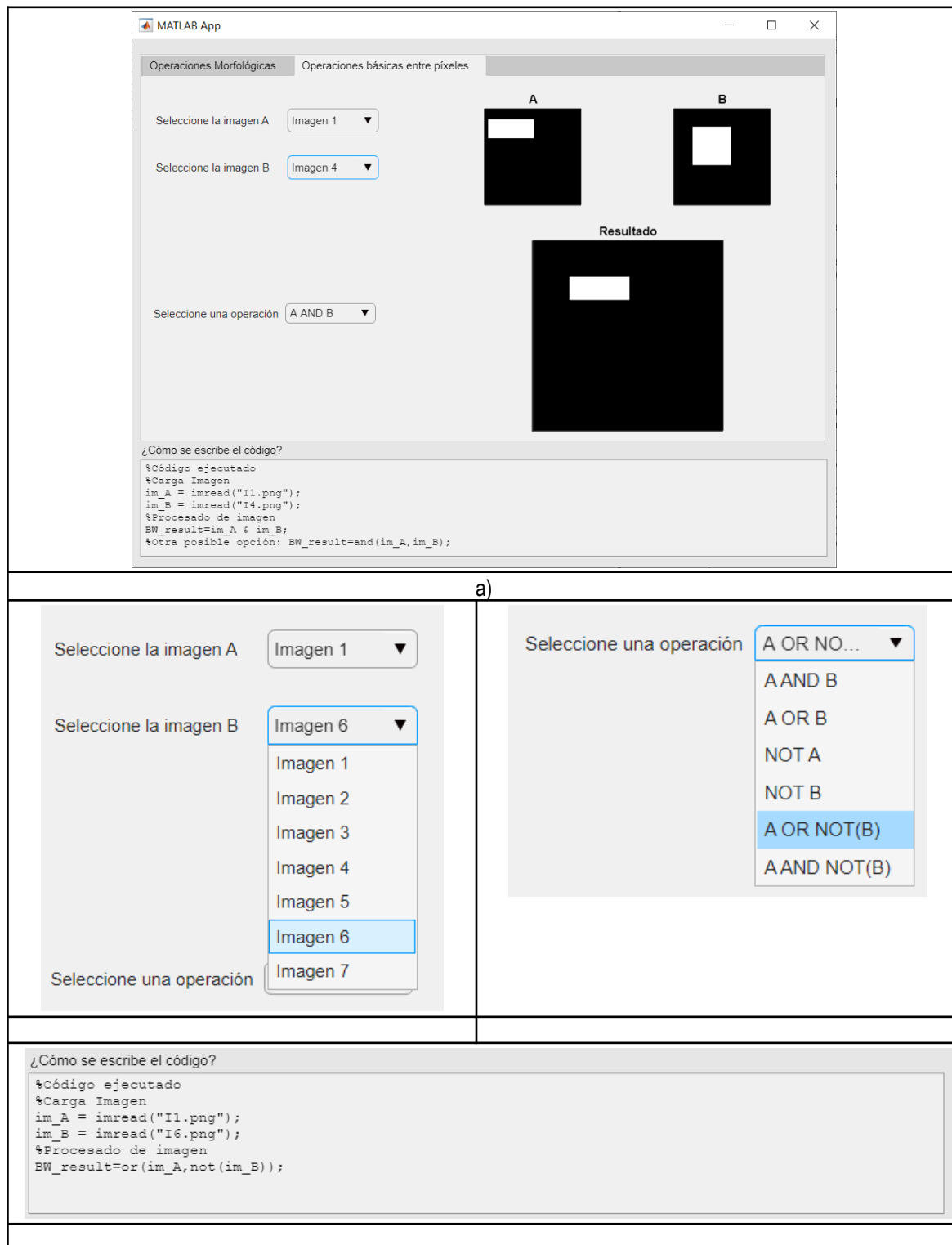


Figure 2. Basic Operations between Pixels tab in the EasyComVi application. a) Appearance of the application. b) Drop-down menu with the possible example images that can be selected. c) Drop-down menu with the different operations that can be carried out. d) Example of proposed code to be implemented in Matlab automatically generated by the application.

Design of the evaluation questionnaire

The EasyComVi tool has been evaluated in the context of a Computer Vision subject in an Industrial Engineering Master's degree. For the evaluation of the tool, a questionnaire has been designed to find out the opinion of the students who have used it. This questionnaire is shown in Tables 1-4. For the assessment, students have been asked to answer the questions by choosing a value between 1 and 5 that indicates their level, or how much they agree or disagree with the issues presented, depending on the type of question.

For a better assessment of the results, the questionnaire has been divided into three main stages:

- A pre-assessment, which seeks to find out the level of the students regarding several areas related to Computer Vision before starting the course.
- An intermediate evaluation, which seeks to know the student's opinion in an intermediate phase, in which the student has already studied part of the theoretical material of the subject but has not yet used the application.
- A final evaluation, which aims to find out the learner's opinion after having used the tool for study.

With this evaluation by stages, the aim is to find out how the student has evolved and the possible usefulness of using the application developed in this article to help during the study, as opposed to studying only the theoretical material.

Finally, a fourth part has been included in the questionnaire, the aim of which is to obtain an overall assessment of the application itself. This last part includes a free space question, which allows the student to express any additional information he/she wants about the application, the process of learning, possible improvements, etc.

Table 1. Evaluation questionnaire. Part 1

Questionnaire: Part 1	N P	1	2	3	4	5
Pre-assessment: What was your level before you started the course? <i>Choose a value between 1 and 5, where 1-None and 5-Very high.</i>						
My level of knowledge of computer vision and image processing.						
My level of knowledge about programming.						
My level of knowledge about Matlab.						
My level of motivation with regard to learning computer vision and image processing.						

Table 2. Evaluation questionnaire. Part 2

Questionnaire: Part 2	2N P	1	2	3	4	5
Intermediate assessment. After studying the written material in the basic bibliography on image processing, and before using the application, how much do you agree or disagree with the following statements? <i>Choose a value between 1 and 5, where 1-Not at all agree and 5-Strongly agree.</i>						
The study of the written material has allowed me to easily understand the basic relationships between pixels.						
The study of the written material has allowed me to easily understand basic morphological operations.						
I am able to visualise approximately what the result of applying basic relations between pixels is when viewing images, without the need to use Matlab or another tool to see the result.						

I am able to visualise approximately what is the result of applying basic morphological operations when viewing images, without the need to use Matlab or another tool to see the result.						
I can easily understand the Matlab examples on computer vision and image processing provided in the course.						
The study of the Matlab examples has allowed me to easily understand the basic relationships between pixels.						
The study of Matlab examples has allowed me to easily understand basic morphological operations.						
I am able to write my own Matlab scripts for the implementation of basic pixel relations examples.						
I am able to write my own scripts in Matlab for the implementation of examples on basic morphological operations.						

Tabla 3. Evaluation questionnaire. Part 3

Questionnaire: Part 3	N P	1	2	3	4	5
Final evaluation. After having used the EasyComVi application to study the subject, how much do you agree or disagree with the following statements? <i>Choose a value between 1 and 5, where 1-Not at all agree and 5-Strongly agree.</i>						
Using the tool has allowed me to understand more easily the basic relationships between pixels.						
Using the tool has allowed me to understand basic morphological operations more easily.						
After having used the tool, I am able to visualise approximately what the result of applying basic relations between pixels is when viewing images, without the need to use Matlab or another tool to see the result.						
After having used the tool, I am able to visualise approximately what the result of the application of basic morphological operations is when viewing the images, without the need to use Matlab or another tool to see the result.						
The use of the tool has allowed me to understand more easily the Matlab examples on computer vision and image processing provided in the course.						
Using the tool has allowed me to understand more easily the basic relationships between pixels.						
After having used the tool, it is easier for me to write my own scripts in Matlab for the implementation of examples on basic pixel relationships.						
After having used the tool, I find it easier to write my own scripts in Matlab for the implementation of examples on basic morphological operations.						

Tabla 4. Evaluation questionnaire. Part 4

Questionnaire: Part 4	N P	1	2	3	4	5
Overall rating of the EasyComVi application <i>Please choose a value between 1 and 5, where 1-Not at all agree and 5-Strongly agree.</i>						
The tool is easy to use.						
I think that the tool is useful to better understand the concepts explained in a theoretical way without the need to have programming knowledge.						
The application has helped me to better understand some of the contents of the subject in an autonomous way.						
My interest in this field has increased after using the application.						
The use of this tool has increased my motivation with the subject.						
I think that the use of the tool can mean an improvement in my performance throughout the course.						

The autonomous learning of the contents of the subject is favoured by the use of this type of applications.							
I think it would be useful to extend this tool to other contents of the subject.							
I think it would be interesting to introduce similar tools to this one in other subjects of the degree.							
Please indicate below any comments you would like to make regarding the tool that have not been reflected in previous questions.							
(Write in this space whatever you want. E.g.: any outstanding positive aspect, any outstanding negative aspect, etc.)							

Dissemination

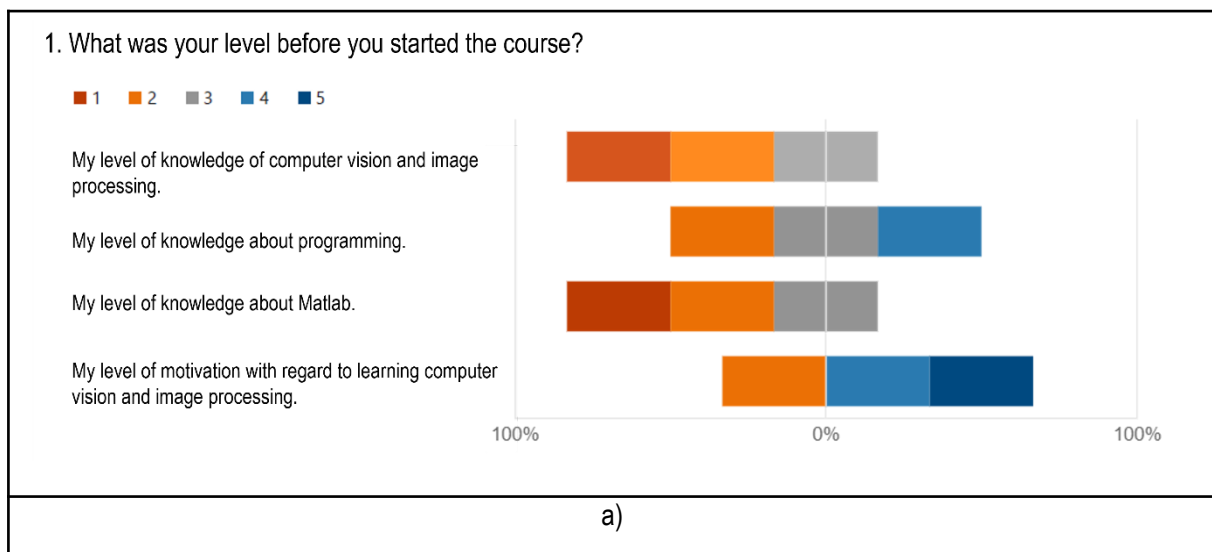
The EasyComVi tool has been disseminated on 3 occasions.

The first time, it was done approximately 2 months after the beginning of the course, so that the students could have had a first approach to the subject using only the theoretical resources and practical programming examples available. In this way, it is possible to evaluate, by means of the questionnaire designed, the students' learning of the contents through the use of only the theoretical-practical material, and through the use of the application developed. This makes it possible to obtain more reliable results in terms of its possible usefulness and the students' satisfaction with it. In this first dissemination, only the tool was offered to the students together with a set of instructions for its use.

The second and third disseminations were made in the middle and at the end of the teaching period by sending the evaluation questionnaire presented in the previous section to the students. The data collection of the evaluation form was carried out by means of a form elaborated in Microsoft Forms, which allows an anonymous data collection, while verified by means of a corporate email account, which on the one hand allows the students to express their opinion in an honest way, and on the other hand, the same person cannot fill in the same questionnaire more than once.

Preliminary results and analysis

In this paper we present the preliminary results obtained in the academic year 2022/2023, carrying out the evaluation in a subject of a Master's degree in Industrial Engineering. Of the 10 students enrolled in the subject, only 3 completed the survey. The results obtained are shown in Figure 3.



2. After studying the written material in the basic bibliography on image processing, and before using the application, how much do you agree or disagree with the following statements?

1 2 3 4 5

The study of the written material has allowed me to easily understand the basic relationships between...

The study of the written material has allowed me to easily understand basic morphological operations.

I am able to visualise approximately what is the result of applying basic morphological operations...

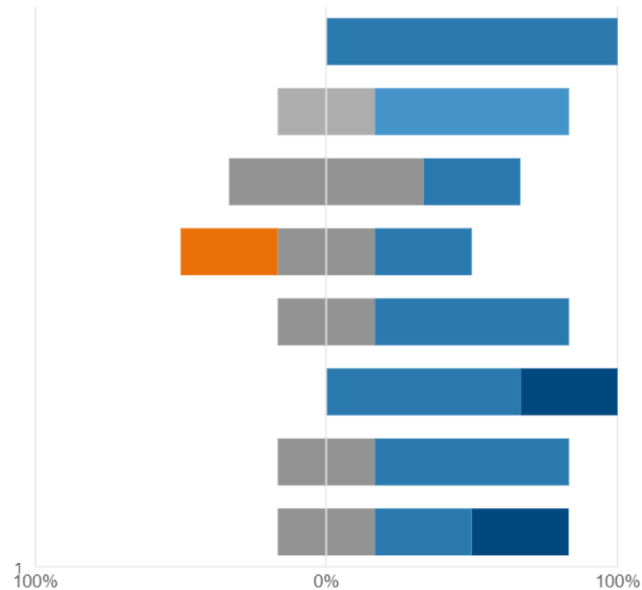
I can easily understand the Matlab examples on computer vision and image processing provided in...

The study of the Matlab examples has allowed me to easily understand the basic relationships between...

The study of Matlab examples has allowed me to easily understand basic morphological operations.

I am able to write my own Matlab scripts for the implementation of basic pixel relations examples.

I am able to write my own scripts in Matlab for the implementation of examples on basic morpho...



b)

3. After having used the EasyComVi application to study the subject, how much do you agree or disagree with the following statements?

1 2 3 4 5

Using the tool has allowed me to understand more easily the basic relationships between pixels.

Using the tool has allowed me to understand basic morphological operations more easily.

After having used the tool, I am able to visualise approximately what the result of applying basic...

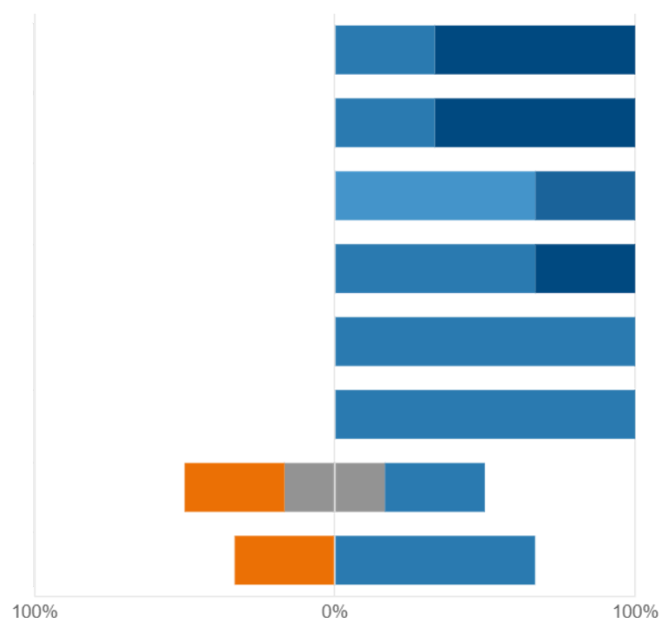
After having used the tool, I am able to visualise approximately what the result of the application ...

The use of the tool has allowed me to understand more easily the Matlab examples on computer...

Using the tool has allowed me to understand more easily the basic relationships between pixels.

After having used the tool, it is easier for me to write my own scripts in Matlab for the implement...

After having used the tool, I find it easier to write my own scripts in Matlab for the implementation of ...



c)

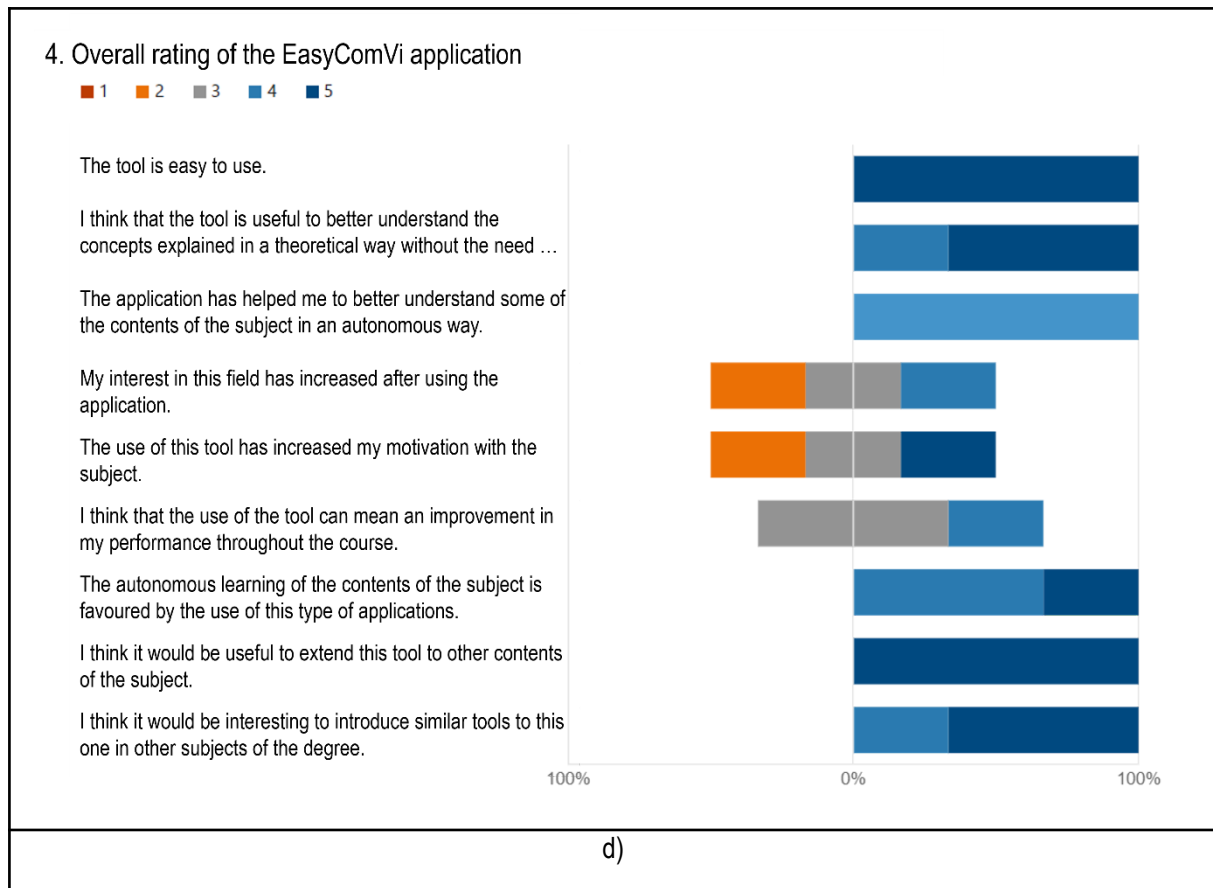


Figure 3. Preliminary results obtained through the evaluation questionnaire. a) Part 1, b) Part 2, c) Part 3 and d) Part 4.

As can be observed in the data presented in Figure 3 a), before starting the course, student's level of knowledge about Computer Vision and image processing and Matlab was among none or medium.

Comparing data in Figure 3 b) (before using EasyComVi Tool) and data in Figure 3 c) (after using EasyComVi Tool), it can be observed that the students can understand more easily concepts about image processing and better visualize the results of applying certain image processing operations after having used the tool developed in the frame of this work.

Finally, if we observe graph in Figure 3 d), we can note that students think that EasyComVi tool is easy to use and is useful to understand better concepts about computer vision studied by means of theory without the need to have programming knowledge. In addition, all students agree that the application has helped them to better understand some of the contents of the subject in an autonomous way. The questions concerning their motivation about the subject and the improvement in their performance along the course were the questions that received lowest values (between 2 and 3). However, the students highly agreed that the use of this type of applications could favoured the autonomous learning of the contents of this subject and that it would be useful to extend the tool to other contents of the subject. Furthermore, students would be interested in the introduction of similar tools to EasyComVi in other subjects of the degree.

Finally, one of the students left an additional comment in the comment box, stating the following: "The effort to develop tools of this style is much appreciated". This, once again, highlights the usefulness of this tool valued by the students.

Conclusions

The study of Computer Vision concepts in distance learning degrees is often a great challenge for students, especially when the main material consists mainly of textbooks, therefore an advantageous educational tool capable of making easier and expanding knowledge can contribute to a better understanding of theoretical concepts.

In this work, EasyComVi, a tool for assisting students in the study of computer vision concepts in distance learning subjects has been described. The tool has been made available to students of a subject on Computer Vision belonging to a Master's degree. The tool has been evaluated by means of a questionnaire. The results obtained are preliminary, but the feedback of the students for this new educational tool is extremely positive. The analysis of the evaluation questionnaires reflects the students' interest in this kind of tool and its usefulness in the study of this type of subject, as well as their interest in extending the tool to other contents of the subject, and even to other subjects.

In the future, the aim is to extend the scope of this innovative educational tool to reach new contents, as well as to improve its design, so that it could provide a better support to students.

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