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A Digital Image Processing Courseware forEngineering Ability Education

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Abstract: *Video andimage processing technology has been widely used in engineering field. In order to shorten the gap between digital image processing course and engineering practice and enhance students' engineering ability, we have developed a courseware for digital image processing course for undergraduates. The project was jointly funded by China's Ministry of education and Intel Corporation. The courseware is an offline HTML package. Each algorithm has executable demo program and source code, which are developed by C++ and OpenCV. Under the support of this courseware, our undergraduates have won many awards in the national software competition.*

Keywords: *educational technology, courseware, digital image processing, OpenCV.*

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I. INTRODUCTION

In the previous decades, due to the limitation of the computing power of the equipment, digital image processing technology is rarely used in the engineering field. Algorithm theory is the main teaching objective of digital image processing course. With the rapid growth of device computing performance, today, digital image processing technology has been widely used in various fields such as society, production and life. Modern educational technology is also applied in this course. So far, many digital image processing courses demonstrate the principle and function of algorithmthrough MATLAB program [1-4]. In recent years, FPGA (Field Programmable Gate Array) platform [5-6] , DSP (Digital Signal Processing) platform [7], or Python program [8-9] is also used as teaching demonstration and experimental tools. However, MATLAB and python programs are more suitable as research tools, and FPGA platform is only suitable for students of specific majors. As CPU + GPU has approached the performance of FPGA, the above several demonstration platforms are not necessarily the best choice for engineering application from the perspective of deployment cost or performance. In contrast, C + + and OpenCV (Open Source Computer Vision Library) schemes can make image processing have better comprehensive engineering performance, and are also suitable for most professional undergraduates.

In order to improve students' ability of applying digital image processing technology in engineering, we developed a teaching courseware based on C + + and OpenCV with the support of the Ministry of education of China and Intel Corporation.The characteristic of this courseware is to integrate the engineering ability training directly into the classroom teaching process.In the classroom teaching, the courseware provides demonstration program and source code for each algorithm, reveals the function and software implementation of the algorithm; in the experiment, students complete their own experimental projects with the demonstration program source code as a reference.

For undergraduates, PCA (Principal Component Analysis) is a very abstract and incomprehensible algorithm. In the courseware, a demonstration program based on Microsoft MFC + OpenCV was developed to reveal the relationship between eigenvalues, eigenvectors and the brightness distribution characteristics of source image pixels.Machine learning technology is an abstract bud very important knowledge module. For the data set marking, training and classification process of SVM (Support Vector Machine) and ANN (Artificial Neural Network), we also developed a demo program using Microsoft MFC + OpenCV, which let students use the mouse to create training data set and reveal the training process and results.

II. COURSEWARE CONTENT AND STRUCT

In recent years, image classification and recognition technology based on various types of neural networks has made great progress, and has been widely used in engineering.In order to adapt to the development of technology, we reorganized the traditional coursecontents. The content of this courseware is organized as follows:

1. Basic operation of image matrix and color space transformation: introduce the storage and access of image in memory, basic operation of OpenCV matrix, and color space transformation.

2. DFT (Discrete Fourier Transform), DCT (Discrete Cosine Transform) and PCA space transformation: are traditional knowledge modules. The principle of PCA algorithm is revealed by additional demonstration program.
3. Image correlation and convolution operation: convolution operation is the basic operation in image filtering and convolution neural network. Image correlation and convolution operation are extracted into a chapter independently to train students' understanding of convolution properties.Convolution operations in space domain and frequency domain are introduced comparatively.
4. Image preprocessing: involves brightness transformation, histogram, low pass and high pass filtering.
5. Image compression and coding: Taking JPEG and H264 as examples, introduces the compression and coding process of still image and video, and uses FFmpeg [10] as the compression and coding and transmission demonstration tool.
6. Image segmentation: involves threshold and region segmentation, edge detection and Hough transform, and moving object detection in video.
7. Image classification and recognition: involves Haar cascade classifier, HOG (Histogram of Oriented Gradients) classifier and SIFT (Scale-Invariant Feature Transform) algorithm.
8. Machine learning technology: involving SVMand ANN. The data set marking and training process of the two algorithms are demonstrated through specially developed software.

The courseware is published to students as offline HTML package. The executable demo program is embedded in the HTML package. In the HTML page, as shown in Figure 1, in addition to the algorithm definition, it also provides the running button of the demo program through JavaScript, and the source code of the demo program is displayed in the foldable HTML document block.While learning the principle of algorithm, students learn the implementation and application method of algorithm in OpenCV C++ through demonstration program and source code. It is particularly beneficial for undergraduates who lack practical programming experience to integrate programming ability training into classroom teaching; it also improves the experimental ability of students.

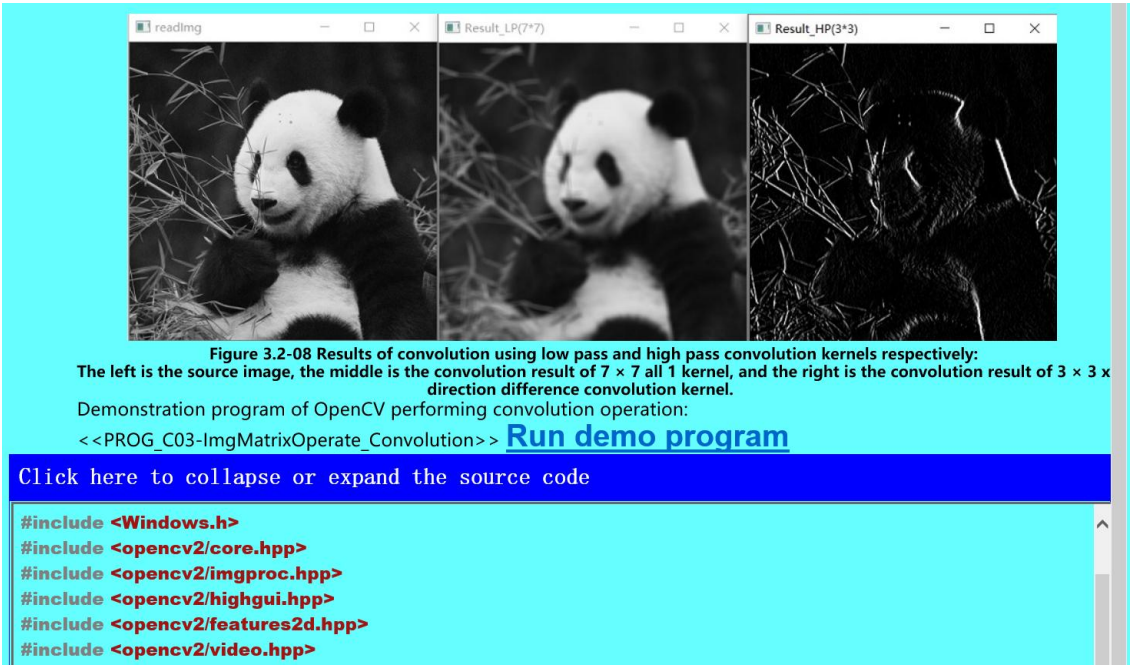

Fig. 1 Demo program and source code onhtml page

The complexity of the algorithm is only a theoretical metric. In C++ and OpenCV programs, time overhead can be used to measure the complexity of each algorithm. Understanding the time cost of each algorithm is helpful to the design and performance tuning of complex application program.

III. CONCLUSION

Teaching practice in recent years has proved that integrating algorithm and OpenCV API into classroom teaching improves the ability of undergraduates to apply digital image processing algorithms in engineering projects. On the other hand, through the study of this course, students' ability of solving problems with mathematical methods in programs is also inspired and improved. In the future, the next goal of our

teaching reform is to let undergraduates master the deployment ability of CNN through the Intel OpenVINO [11] toolkit and evaluate the performance of various pretraining CNN models in engineering practice.

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