Construction of an Edge Computing Based Innovative Cloud Platform for Simulation Teaching

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Abstract. With the rapid development of recent computer, Internet and other advanced technologies, virtual simulation platform has emerged in teaching procedure, which has changed the traditional teaching mode on experimental practice, and broken through the time-space limit of the experimental operation on class. However, construction of a real time web-based virtual simulation system is challenge, especially for the cause like digital image processing. Using the XOJO development platform and combining network programming with edge computing, our system has strong portability, convenient deployment, simple operation, low latency, and wide applicability, which can be applied not only to college experimental teaching, but also to other digital image processing amateur and researchers. By visiting this platform with cell phone or other portable devices, students can master the key technologies of digital image processing such as image segmentation technology, image enhancement and restoration technology, texture feature analysis, image feature extraction technology, medical image 3D modeling during theoretical class hours. The result shows that students are able to learn the basic theoretical knowledge easily and apply the function module options provided by the system to solve specific class problems.

Keywords: virtual simulation teaching · cloud platform · XOJO · edge computing

1 Introduction

From the report of the Twentieth National Congress of the Communist Party of China, education, science and technology, and talents are putted into an overall arrangement and deployment "promoting education digitalization" into the report for the first time, which gave education a new mission and task of great significance.

With the rapid development of recent computer, Internet and other advanced technologies, virtual simulation platform has emerged in teaching procedure as a part of

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education digitalization, which has changed the traditional teaching mode on experimental practice, and broken through the time-space limit of the experimental operation on class. However, construction of a real time web-based virtual simulation system is challenge, especially for the course like digital image processing.

The course of "digital image processing and analysis" is an important professional basic course for major in electronic information engineering and communication engineering. Because the basic principles of digital image processing are often explained with relatively abstract mathematical expressions, it is difficult for students to form an intuitive and perceptual understanding of image processing. On the other hand, digital medical technologies represented by 3D medical image reconstruction, virtual reality technology, machine learning, 3D printing, etc. have shown a wide range of application prospects in clinical practice. At present, various high-end technologies including image-related artificial intelligence are all based on 3D image reconstruction. The 3D reconstruction results of medical images can be used for 3D printing, computer virtual reality surgery, and medical surgery teaching, Distant surgical operation and disease diagnosis. However, the time of 3D reconstruction of traditional medical images is too long, and special software platform is required, while the portability is poor. Due to the large amount of data in the image processing of the traditional simulation platform implemented by network programming, the delay of network computing processing is serious, and the effect of some use scenarios with high real-time requirements is not satisfactory. In recent years, a new computing model, edge computing, has been introduced. This computing model refers to processing data at the edge of the network, which can reduce the response time of requests, while ensuring the security and privacy of data [1–6].

In this study, we build a digital image processing teaching and scientific research cloud platform based on edge computing with network technology, cloud platform, and the new computing model edge computing launched in recent years. This platform is based on the XOJO network programming framework, combined with edge computing and FPGA to accelerate image processing, break through the limitations of time and space, network equipment, programming language, etc., and establish a real-time online, real-time update, open source interactive teaching and research platform in the Internet of Things era.

2 Method and Material

This simulation platform has a wide range of application scenarios, which blurred the difference between virtual and reality is, and the teaching mode of "combining virtual and real" is achieved. The component of cloud system is as below:

2.1 XOJO Cloud Platform

The digital image processing technology virtual simulation teaching and research system designed by this simulation platform is based on XOJO network programming platform, which is developed using B/S architecture, that is, Web browser is the main application software of the client. This mode unifies the client, centralizes the core part of system

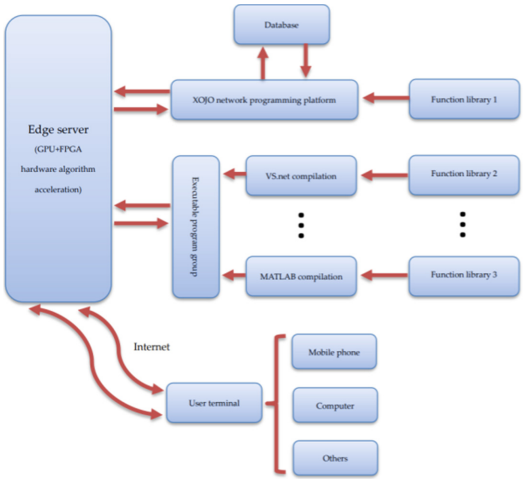

Fig. 1. Cloud Platform Framework

function realization on the server, and simplifies the development, maintenance and use of the system. Only one browser is required to be installed on the client computer of this system. The server has installed the MYSQL database and the executable programs used by edge computing. They communicate with each other through XOJO, and finally deployed on the web page and pushed to the client, as shown in Fig. 1.

XOJO is a development tool for cross-platform programming language and visual development interface. It supports cross-platform development and development of multi-platform applications. Through cross-compilation, applications for Linux system can be developed on Windows system, and applications for Mac OS X system can also be developed. In addition, multiple types of platform programs can also be developed on the same system, such as desktop applications, network programs, console programs, iOS mobile platforms, etc. This system uses the development function of its network programs. Some image algorithms with small amount of computation, such as the calculation of texture features, and the operation management of some databases can be implemented on the XOJO platform, but for image algorithms with large amount of computation, such as deep learning, 3D modeling, and other programs, edge computing needs to be used for network acceleration, that is, image processing programs are run in the server background.

2.2 Edge Computing

Unlike XOJO network programs, programs at the edge are not executed on the network channel, but reside on the server in the form of executable program groups. The user sends a message through the browser, parses it through the XOJO web page platform, and transmits it to the corresponding executable program residing at the edge. After the program responds to this command, it will process the data locally, and after the calculation, the corresponding results will be returned to the client through the Internet or local area network, and finally presented in the user interface. Because the executable program

at the edge can be generated by any programming language, such as VS. Net, Python, Matlab, etc., the platform has good constructability. The platform encapsulates various basic algorithms of image processing in a unified way, and integrates and develops them with OpenCV class library; At the same time, uniform standard interface parameters are designed and provided to form the algorithm processing core module. This design makes the client application not limited by the user system platform and can be extended on the mobile platform.

2.3 FPGA Acceleration

For some time-consuming algorithms, such as the 3D modeling program in the experiment, to ensure that the modeling time is controlled within 1 min, the local operation part of edge computing uses FPGA to accelerate the relatively time-consuming algorithm. FPGA (Field Programmable Gate Array) is a typical parallel computing chip with fast operation speed and high stability. The FPGA acceleration in the experiment uses PYNQ chip. PYNQ adds support for python on on the basis of the original Zynq architecture, which is a heterogeneous SOC integrated with ARM processor and FPGA programmable logic device. Compared with traditional algorithms, the operation speed has been improved by dozens or hundreds of times, the power consumption has been significantly reduced, and the cost is also low.

2.4 Image Acquisition Engine

When the user wants to use the image provided by the system for experiment, the image provided by the system is output to the user interface through the image acquisition engine, and the result of the final image processing at the edge end will also be displayed and output through the image engine. The image engine is developed in VS programming language and resides in the edge server with executable programs.

2.5 Image Processing Function Library

The image processing performed by users on the cloud platform is based on the encapsulated functions of the system. By adding a variety of image processing libraries, users can enrich their operations. Common image processing libraries include OpenCV, CxImage, etc. The full name of OpenCV is Open Source Computer Vision Library. OpenCV is a cross-platform computer vision library based on (open source) distribution, which can run on Linux, Windows and Mac OS operating systems. It is lightweight and efficient - composed of a series of C functions and a small number of C++ classes. It also provides interfaces for Python, Ruby, MATLAB and other languages, and implements many common algorithms in image processing and computer vision. Different function processing libraries are encapsulated and compiled by Matlab and VS.net to reside at the edge as executable programs for user data processing.

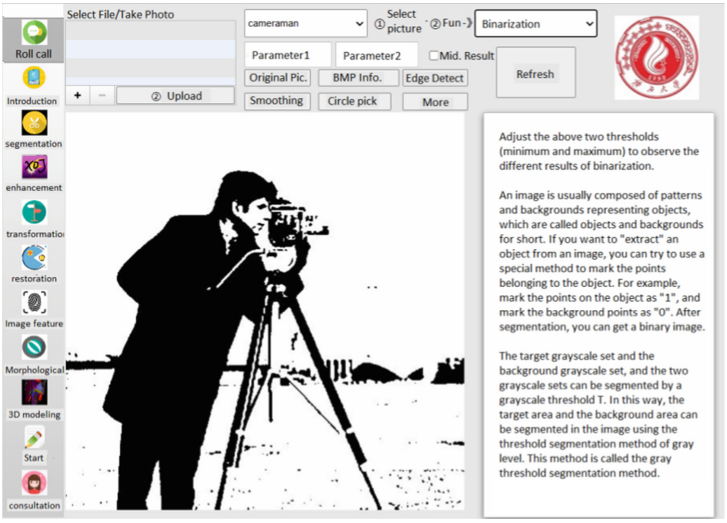

Fig. 2. Image segmentation

3 Results

3.1 Basic Algorithm Experiment

The virtual experiment platform selects the functions that may be involved in the comprehensive design experiment from the image processing function library, and packages them into several function blocks to call. A button control on the GUI corresponds to a function block function, which includes threshold segmentation and edge detection of image segmentation technology; Median filtering of image enhancement and restoration technology; Texture feature analysis of image feature quantity; Corrosion and expansion of image morphology processing; Six modules, including circle extraction based on tag technology and tilt correction based on Hough transform.

As shown in Fig. 2, the experimental image "cameraman" that comes with the system is selected from web, and the threshold of binarization is selected: 20 and 130. The processing results under this threshold are displayed below, and the content on the right of the image is an introduction to this operation for users to understand.

3.2 Comprehensive Experiment

After completing the above six basic algorithm validation experiments for image processing, users can conduct comprehensive experiments, as shown in Fig. 3. Click the “Start Experiment” button to enter the comprehensive experiment module. There are 12 drop-down menus for the user to select. The user can select different processing functions to process the image in each step. If you do not select the processing function, the default will be straight-through. Click Run after the selection is completed, and the image processed in 12 steps will be displayed in the box on the right. The experimental results are shown in Fig. 3.

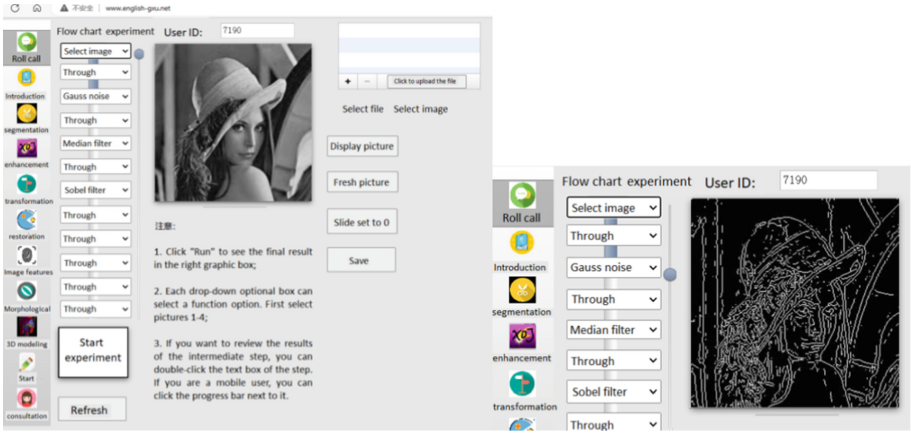

Fig. 3. Comprehensive experimental results

4 Conclusion

In the process of education and teaching, students can ask questions on the platform, and teachers can release sign-in, answer questions and answer relevant questions on the platform. At the same time of teaching, we can understand the students' grasp of classroom knowledge in time, so that we can explain relevant knowledge pertinently and improve the efficiency and quality of classroom teaching.

This simulation platform uses network programming and edge computing technology to speed up digital image processing while saving users' local resources, reducing the requirements for users' digital image processing programming capabilities, and can be widely used in digital image processing teaching, scientific research, and medical image modeling. In recent years, the digital image processing market has grown rapidly. In 2020, the market size of the digital image processing application end has reached 21.73 billion RMB, with an annual compound growth rate of 252.4%. It is expected that the market size will grow to 60.15 billion RMB in 2025, with an annual compound growth rate of 94.2%. However, there is no similar digital image processing network programming platform at home and abroad, so it will have a very broad use and market prospects.

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