CNN-based Image Recognition and Processing Technology
Development of Airborne Display and Control System

Jinsong He¹*, Xiaojun Li¹ and Jia Xiao¹

¹ Communication College, Shanghai Technical Institute of Electronics & Information, Shanghai, 201411, China
* hejinsong2010@126.com

Abstract. The test system is designed for the MDU unit of the airborne display and control subsystem, and the test software is developed based on LabVIEW. The CNN image recognition and processing technology is used to realize the image recognition and test functions of the MDU unit. The image data collection system collects 8 channels of analog signals, converts the data collected in each channel, and then outputs the whole image, so as to obtain a complete frame of image information, combined with the threshold shrinkage and the two coefficients of noise pollution by judging the degree of noise pollution image noise reduction processing, image text recognition processing based on CNN and image CNN model training. Experimental results show that the test system can successfully realize the functions of recognition, analysis, detection and processing of displayed images.

1. Introduction
As an important part of the avionics system, the airborne display and control system, its image information display performance and image quality directly affect the overall safety of the aircraft. Generally speaking, it has very important significance[1].

Based on the design and development of MDU unit test system of airborne display control subsystem, this paper successfully realized the image recognition and test function of MDU unit by using CNN image recognition and processing technology[2][3].

2. MDU unit image processing requirements
The image recognition function must capture the current MDU display screen according to the instructions of the test case execution function, support the simultaneous capture of the display screens of the two monitors; the image acquisition device has a clock synchronization function that supports clock synchronization with the test equipment. The collected images are time-stamped; each collected image is automatically stored and associated with the test case. After the image collection is completed, the automatic recognition function performs automatic image recognition and result judgment.

The image recognition function supports importing and parsing DF files, using each element in the DF file as the recognition unit for automatic image recognition. It also supports importing non-661 display screen xml files, and can use the elements of the display screen template as the recognition unit for automatic image recognition.

3. system structure
CNN is a multi-layer perceptron specially designed for recognizing two-dimensional images. This system will use CNN method to recognize the image of the airborne display and control system, and
use the two-dimensional image as input[4]. Factors such as camera exposure, focus distance, etc., so that the quality of the final image to be identified is difficult to be guaranteed. Performing the necessary image pre-processing is of great significance for subsequent recognition of text characters, icon recognition, and line type transformation.

The structure design of image acquisition and automatic recognition function in this system software is shown in the following figure1.

![Image processing technology structure design drawing](image)

**Figure 1. Image processing technology structure design drawing**

The main processes used in the image processing process include: image data set construction, image noise reduction processing, image text recognition processing and image CNN model training.

4. **Function development**

4.1. **System software design and development**

The system software program includes platform program, bus test program, unit test program and video test program. The overall composition is shown in Figure 2.

![System software composition](image)

**Figure 2. System software composition**
4.2. MDU test function development

The main functions of the MDU test program include MDU display image test, MDU fault data download test, MDU and UMC communication test, and MDU HDLC communication function test. The MDU test (client) program controls the image information displayed on the MDU display by sending MFL commands, and at the same time calls the image processing program to identify and process the MDU display screen, thereby testing the image quality and other related technical indicators of MDU display. The MDU test process is shown in Figure 3.

5. Key technology

5.1. Image acquisition technology

The image data acquisition system has to complete 8 channels of analog signals, with a resolution of 16 bits and a sampling rate of 10 MS/s; 8 channels of digital serial signals and 1 channel of parallel digital signal. The sampling frequency of analog signal acquisition and digital signal acquisition is obtained from the 10MHz external clock through the onboard phase-locked loop frequency multiplication and phase lock. Both the external trigger clock and the sampling clock use external clocks, which are uniformly generated by the AWG5012B arbitrary waveform generator. The trigger signal is the frame synchronization signal. When the data needs to be collected, a trigger is generated from the outside, and the acquisition starts from the frame head of the image matrix until a complete frame of image data is collected. The onboard storage space of the analog data acquisition module and the digital data acquisition module is designed to be larger than 200M Bytes, to ensure that the continuous acquisition of 100 frames of complete image data is not covered.

The acquisition software is developed based on LabVIEW. The main tasks include the following:

1) Pulse signal editing and generation, mainly including clock signal editing and generation, frame synchronization signal editing and generation, line/field synchronization signal editing and generation, and synchronization trigger signal editing and generation.
2) There are two modes of data acquisition and image conversion. The image output direction has two modes, output by row and output by column. Therefore, the data processing part is designed as an adaptive adjustment mode, and different image space-time conversion matrix algorithms are called according to the characteristics of the frame header signal. Convert the data collected by each channel and output it as a whole to obtain a complete frame of image information.

The algorithm is introduced as follows:
- Extract the n-channel data collected to obtain image data;
- Reorganize the image data to obtain a one-dimensional array of all image data;
- Intercept one-dimensional image array data according to a specific data structure to obtain a one-dimensional array of image data for each frame, and combine them into a two-dimensional image pixel matrix (two-dimensional array) according to the pixel size of each frame of image.

5.2. Image noise reduction

This system uses wavelet threshold denoising based on wavelet domain. Its specific technical operation is implemented as follows: this system combines two kinds of wavelet noise reduction methods: threshold shrinkage and the degree of noise pollution by judging coefficients. The first one is to set the appropriate threshold, set the coefficients smaller than the threshold to zero, and retain the wavelet coefficients larger than the closed value, get the estimated coefficients through the threshold function mapping, and finally inverse transform the estimated coefficients to achieve denoising and reconstruction[5][6]. Another method introduces various measurement methods by judging the degree to which the coefficient is polluted by noise. According to the noise reduction results of different scene images, the best noise reduction algorithm is selected to complete the image noise reduction[7].

5.3. Image text recognition processing

Text recognition is the most complex and challenging application of the system, involving image processing technology, feature extraction technology, feature classification technology and text error correction technology. Aiming at specific application scenarios, this system establishes an end-to-end CRNN text recognition system that integrates feature extraction, text classification and semantic error correction[8][9].

At the bottom of the CRNN, the convolutional layer automatically extracts feature sequences from each input image. At the top of the convolutional network, construct a recurrent neural network for predicting each frame of the feature sequence output by the convolutional layer, and use the
transcription layer to convert each frame of prediction into the final label sequence to complete semantic error correction[10].

5.4. Image CNN model training
CNN convolutional neural network training is mainly divided into two stages: the first stage, the forward propagation stage:

1) Select the training data set (the MDU display image is collected and stored as a training sample by a high-performance camera);

2) Randomly initialize the weights and offsets in the network, as well as the initial learning rate and sample error threshold, manually set the initial learning rate, the size of the learning rate affects the adjustment range of the weights. Excessive learning rate may cause the adjustment of weights during training to miss the optimal value, and the network diverges. Too small a learning rate may cause the network to fall into the dilemma of local optimization. The initial learning rate is highly empirical, and generally depends on the specific analysis of the specific problem, usually set at [0, 0.1, 0.8];

3) Select a vector input network from the training sample set and send it to the output layer. The network calculates the dot product of the input and the weight matrix of each layer by layer, and finally obtains the output result.

The second stage, the backward communication stage:

1) Calculate the actual output value of a single sample vector and the error value from the ideal output value;

2) According to the minimization error method, the error value in step 1 is back-propagated layer by layer to adjust the weight, offset term and threshold in the network;

3) Determine the size between the total error value of the network and the given error threshold after adjusting the weights. If the total error value is less than or equal to the given error threshold, go to the step 2. If the total error value is greater than the given error threshold, the network has not reached the expected target and needs to continue training and return to step 3 in the first stage;

4) After the training, save the parameters in the network in a stable state.

6. Results and verification
By analyzing the test results of loading the standard barcode diagram and the actual display image of the MDU device to verify the algorithm, we can see that the CNN-based image recognition and processing algorithm can successfully realize the recognition, analysis, detection and processing of the displayed image and other functions.

![Figure 5. Standard image](image-url)
Figure 6. Test image

References

[1] ZHOU FeiYan, JIN LinPeng, DONG Jun. Review of Convolutional Neural Network. Chinese Journal of Computers, 2017, 06(40): 1229-1251.
[2] Lu Hongtao, Zhang Qinchuang. Applications of Deep Convolutional Neural Network in Computer Vision. Journal of Data Acquisition and Processing, 2016, (01): 1-17.
[3] YU Ruijie, YANG Zhen, XIONG Huilin. Aircraft detection and recognition based on deep convolutional neural network. Journal of Computer Applications, 2017, 37(6): 1702 – 1707, 1715.
[4] Yin Xie, Yan Lei. Image Object Detection Based on Deep Convolutional Neural Network. Industrial Control Computer, 2017,30(04): 96-97,100.
[5] YOU Bo, ZHANG Chenfeng. Image noise reduction combining wavelet adaptive threshold and bilateral filtering.COMPUTER ENGINEERING AND DESIGN, 2019, 8(40): 2278-2282.
[6] QIANG Yan, ZHANG Xiaohui. Image de-noising method based on wavelet transform and bilateral filter in vehicle gesture recognition. Transations of Beijing Institute of Technology, 2017, 37(4): 376-380.
[7] Cao Jingjing, Hu liaolin, Zhao Rui. Improved threshold de-noising method of fiber bragg grating sensor signal based on wavelet transform.Chinese Journal of Sensors and Actuators, 2015, 28(4): 521-525.
[8] Jin Ying Wang, Xueying Duan, Linmao Surface defect detection of inner groove in plunger brake master cylinder based on LabVIEW and Mask R-CNN. Modern Manufacturing Engineering., 2020, (05): 125-132.
[9] CHEN Kui, XING Xueyan, TIAN Xinyi, WANG Jihao, WANG Shun. Systematic Design of Face Recognition Access Control Based on CNN. Journal of Xuzhou Institute of Technology(Natural Sciences Edition), 2018,(04): 89-92.
[10] Li Kangshun, Li Kai, Zhang, Wensheng. PCA FACE RECOGNITION ALGORITHM BASED ON IMP ROVED BP NEURAL NETWORK. Computer Applications and Software, 2014, 31(01): 158-161.