Exploration and Research of Noise Automatic Processing Algorithm Based on Multi-scale Convolution Neural Network

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Abstract. This paper introduces the secondary development process of simcenter Test.Lab software. Using simcenter Test.Lab software's multi language support and its advantages in noise test and analysis, combined with computer image recognition technology, an automatic noise processing algorithm system (LMS Test.Lab) based on Simcenter Test.Lab software test data is developed. The system is simple to use, high accuracy of data recognition, and can intelligently judge specific abnormal conditions. Engineers can use the secondary development program to do intelligent processing of specific data and automatic generation of test reports, which effectively improves the accuracy and efficiency of automatic data processing.

1. Introduction
Noise is a branch of acoustics, in fact it is related to everyone [1]. For example, most products in home appliances have noise problems [2]. As for the noise of household appliances, the dynamic signal processing and analysis system of noise and vibration is one of the important fields of current engineering. Through the analysis system, the whole process collection of noise and vibration test information and results can be realized [3]. Sound can transmit correct product features and functions, and sound quality testing solutions can be used for noise level benchmark testing, evaluation and troubleshooting [4].

At home and abroad, some professional noise modal test and analysis software have been developed to assist engineers to do better vibration acoustic design, such as Simcenter Test.Lab of Siemens, DASP of Dongfang Institute, etc. This kind of general commercial software integrates the mainstream data processing methods, provides a convenient interactive interface, and improves the work efficiency of engineers. However, for large household appliance enterprises, in the face of many product categories and different working conditions, they put forward some personalized requirements for the software, such as the rapid identification of specific product specific abnormal sound, the rapid generation of quality report and so on. The functions of the software can no longer support. But commercial software will generally provide personalized customized interface to realize function expansion and meet the needs of customers. Among them, Simcenter Test.Lab supports the secondary development of Visual Basic, Visual C++, C sharp and other languages, which provides convenience for function expansion.
Based on the support of Simcenter Test.Lab for Visual Basic language, this paper develops a whole process data post-processing analysis program which can automatically analyze and process data and automatically issue analysis report. Users can effectively and quickly realize data processing and report output by simply interacting with the program, which greatly simplifies the user interaction operation. The intelligent identification module can identify and analyze the characteristic data with high precision, further improve the efficiency of the engineer, and let the engineer free from the repetitive and complicated mechanical operation, and devote more energy to the vibration acoustic design.

2. Basic principles of secondary development
Simcenter Test.Lab provides a programming interface based on COM (component object model). When the program is installed in Windows system, the program will automatically register an open interface in the system, create a new Visual Basic program project in visual studio, add a reference to COM, find LMS Test.Lab and complete the reference, you can call Test.Lab in the Visual Basic project and realize the function you want [5]. For the special code of Test.Lab, please refer to its help document automation manual or Test.Lab program tool automation documentation tool.

3. Multi scale convolutional neural network algorithm architecture

3.1. Program logic framework
A complete noise test experiment is generally divided into several processes: sample preparation, sensor layout, software settings, data acquisition, data processing, data analysis and writing test analysis report. Among them, based on certain conditions, in addition to data analysis and its corresponding analysis report, other processes can be solidified. Therefore, the whole secondary development logic is a solidifiable process to achieve one-click operation, and non solidifiable auxiliary processing based on artificial intelligence to achieve the purpose of reducing repetitive labor and improving work efficiency.

Simcenter Test.Lab itself is an excellent data processing and analysis software. Therefore, the whole secondary development makes full use of its online data processing module to realize online data post-processing, which can effectively reduce the amount of code. The code focuses on data extraction, data analysis and report generation. The test software itself is mainly responsible for data collection and data processing, and the secondary development program is mainly responsible for standard import, data analysis and final report generation. The main execution logic of the program is shown in Figure 1.
3.2. Data processing and analysis basis

The equipment establishes the noise test and evaluation standards, which provide a reference for the data processing, and also solidify the evaluation standards into the program to standardize the test process and reduce the human operation error. At the same time, engineers from all categories of work are organized to formulate acoustic evaluation of corresponding categories, obtain typical characteristics of noise of each category, and provide judgment for the automatic analysis of data.

As shown in Figure 2, on the left is the noise curve of a certain type of soybean milk machine when simulating the user's soybean milk beating, and on the right is the partial enlarged picture of the frame selection part. It can be seen from the image that the noise of the soybean milk machine is constantly changing during the whole pulping process.

Combined with the actual working situation, it can be seen that frame selection 1 is the noise in the fast heating stage, at this time, the motor does not work, only the heat pipe works. The noise curve is similar to that of a kettle. Frame selection 2 is the noise produced when crushing beans. At this time, the motor will work intermittently, that is, after the motor drives the blade to rotate at high speed for a period of time, it will stop for a few seconds, and then continue to start rotating for a period of time, and then stop for a few seconds, so as to achieve the purpose of crushing food materials. The figure shows two churning cycles. It can be found that the churning noise between cycles is similar. There is a peak at the beginning of each cycle, and then it tends to be flat. The corresponding working condition is that the motor starts suddenly, and there will be a start-up noise when the soybean milk is driven to rotate in the acceleration stage. When the flow field tends to be stable, the noise starts to be stable. Frame selection 3 is the noise generated by intermittent heating. In this stage, the heat pipe works intermittently, and the intermittent work of the heat pipe is conducive to preventing the bottom from sticking. Due to the short time interval of the heat pipe breaking, the noise shows small peaks, and the overall noise amplitude is very small in this stage. Frame selection 4 is the buzzer sound after the whole pulping. The tester will stop the test after seeing the prompt sound signal.

Based on the decomposition of soybean milk machine noise curve, we can know that different graphic styles correspond to different working states. Through the decomposition of noise amplitude in time domain, combined with work experience, we can accurately judge the actual working situation of soybean milk machine. Using artificial intelligence deep learning.
framework combined with image processing algorithm can effectively identify these image features. As long as the image features are combined with the engineer's experience, the product working condition can be output, and the purpose of automatic data analysis can be achieved.

3.3. Introduction to secondary Development Program

COM provides a specification for sharing binary code between different applications and languages, which defines the way of software components communicating with each other [6]. Therefore, in theory, whether using Visual C++, C sharp or VB or other languages can complete the secondary development. Considering that the Test.Lab help document is mainly based on the introduction of Visual Basic 6.0, the secondary development program is mainly written in VB language, and the intelligent image recognition module is mainly written in Python language.

The recognition module is mainly based on the deep learning framework TensorFlow, Inception-v3 model, and uses the DTW (Dynamic Time Warping) method in speech recognition. At the same time, the data augmentation method is used to enhance the robustness of the algorithm and further improve the recognition accuracy. In the case of limited data training, the comprehensive test recognition accuracy reaches 97.9%. The structure of convolution neural network is shown in Figure 3.
The Inception-v3 model uses different convolution kernels of different sizes to extract different levels of feature images, which can reduce the grid size between different modules. 0-padding convolution is used to keep the mesh size, and inside the Inception module, 0-padding convolution is also used to keep the mesh size. Decompose the convolution of large-scale kernel, and decompose the large-scale convolution kernel into small-scale convolution kernel, as shown in Figure 4.

4. Application examples

Taking the automatic analysis of soybean milk machine noise data as an example, the basic operation process consists of four steps:

(1) In the interface of secondary development program, soybean milk machine is selected as the analysis type;
(2) Select the data to be analyzed automatically;
(3) Click the export data button to open the image recognition program;
(4) Click generate report to output the report automatically according to the result of program analysis.

After the program reads the data correctly, it will automatically open the identification module and output the identification results according to the prefabricated identification logic. The program running interface is shown in Figure 5.
Figure 5. Operation rendering of intelligent image recognition module

After recognition, the judgment conclusion is saved in a TXT file. Click the generate report button to read the content of the TXT file in the preset path and output the word document, as shown in Figure 6, which is the first page of the report. In the first page, the whole noise test situation can be intuitively obtained, and the complete intelligent recognition analysis results can be output in the inspection conclusion. It can partly replace the engineer's analysis. It can be seen from the analysis results that the whole test duration and the number of stirring cycles are given, which can enable the electronic control engineer to quickly judge whether the machine is running according to the planned electronic control program. It also gives the maximum average noise, the maximum noise, the average noise of stirring, the abnormal sound judgment and other noise analysis, so that the noise engineer can quickly understand the noise situation of the machine.

5. Summary

1. Using image recognition method combined with deep learning algorithm to solidify the engineer's data processing experience into the secondary development program. At present, it can partly replace manual data analysis, and with the continuous iterative optimization, its analysis scope and ability can be continuously improved.

2. Through the secondary development, the automatic report function is realized, which greatly improves the efficiency of data post-processing.

3. Based on the secondary development of Simcenter Test.Lab, the automatic analysis module is compiled for five small household appliances, including soybean milk machine, electric kettle, fan, wall breaker and induction cooker. The program can be continuously expanded and upgraded.

4. The corresponding category test standards are written into the program, and the test process is standardized through the program, which improves the degree of standardization.
### Noise Test Report

| Sample Name / Model | W71 | Sampling Unit | Basic Science and Simulation |
|--------------------|-----|---------------|-------------------------------|
| Test Executor      |     | Sampling / sending person |                               |
| Nominal noise value| 70  | Inspection category | noise                        |
| Number of samples  | 1   | Sampling / sample delivery date |                           |
| Test conditions    |     | Voltage: 220 V | Frequency: 50 HZ | Ambient temperature: 24 °C |
| Sampling conditions|     | Sampling frequency: 50 HZ | Frequency resolution: 2 HZ |
| Test conditions    |     | W71 - soybean milk stall - stirring whole process - machine NO.4 |                           |
| **test result**    |     | Instantaneous maximum sound power in the process | 83.8 |
|                    |     | Average value of sound power in the process | 69.81 |
|                    |     | Difference between the maximum and average value in the process | 13.99 |
|                    |     | Vibration acceleration | / |

#### Test conclusion

The whole test time is 2198 seconds, the maximum noise of the bean touching stage is 83.8 dB, which appears in 288.5 seconds, and the maximum noise of the whole test is 83.8 dB, which appears in 288.5 seconds, which is consistent with the bean touching noise, indicating that it is caused by the bean touching. The average sound power of the whole stirring process is 75.56 dB, which appears in the 6 stirring cycle. The maximum average sound power of the later stirring level is 65 dB, which appears in the 19th cycle, after intelligent identification, there is no empty play.

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**Figure 6.** The first page of the automatic analysis report

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