Design of Visual Online Spectrometer Based on Support Vector Machine

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Abstract. Using the ARM and DSP dual core processor and H.264 algorithm to study the iron spectrum image classification technology, the typical oil sample image is scaled, stable and rotating, and a complete grinding grain sample library is established. By using a Vinci processor, H.264 encoding method, the Visual on-line iron spectrometer that can be used to monitor the visual line of the wear particles in the oil and meet the requirements of on-line oil monitoring is produced. The iron spectrometer is supporting vector machine and recognition accuracy are ideal.

Introduction

With the rapid development of computer technology, network communication technology and data fusion technology, the online oil monitoring technology is developing in the direction of automation and intelligent. The online oil monitoring and diagnosis system is developing in the direction of network and remote, and the automatic digital image recognition technology which is a new hotspot in the study of iron spectrum. The digital parameter description method with high resolution FTIR micrographs has improved the analysis of the iron spectrum image to the digital level, and online digital spectrum of digital image analysis will be an important basis for the development of online iron spectrum technology.

The Overall Design

Image processing with Vinci framework and H.264 algorithm with ARM and DSP dual-core architecture can improve the processing speed of oil sample abrasive samples, and then develop high-performance online oil real-time image processing system.

Workflow

When the image can be seen on-line ferrometer work, first to the mixed magnet plus forward voltage, and adjust the oil flow in the flow rate, so that the abrasive particles in the high gradient and strong magnetic field under the size of the orderly deposition; The gear pump in the mixed magnet under the conditions of power under the suction, blowing the remaining oil in the flow channel; and then a few minutes later, the image sensor in the computer control under the control of the abrasive image; mixed magnet reverse power, the deposited abrasive High-speed flow of oil samples washed clean. Through the above operating sequence, the image can be seen on-line ferrometer can be observed in the opaque oil samples of the abrasive function. Then, the typical oil sample size scale, smooth and then use the visual feature, the spectral measurement method and the wavelet statistical method to detect the abrasive grain characteristics of the oil sample image, and then use the improved visual attention model to detect the abrasive grains. The function of support vector machine is used to calculate the target characteristics of primary vision, spectrum characteristics and statistical features. The kernel function uses RBF function and the cross validation method to carry out performance test[1].

Hardware Design

Dedicated computer system hardware platform to Vinci technology DSP+ARM dual-core processor as the core, the use of Vinci framework and H.264 algorithm components to build a high-quality,
low-cost SIP-based streaming media transmission system. Through the DSP encoding module, SIP signaling control module, RTP/RTCP real-time data transmission module, DirectShow playback module, the use of third-party companies to provide digital video software development kit, SOC view of the analyzer, integrated development tools, Provide middleware, build embedded video surveillance platform. Through my eclipse build integrated development environment, built with sqlite3 embedded database, application HTTPD, apache-tomcat, JDK and other software, application JAVA component programming technology to create WEB server[1] [2].

Image Processing Scheme

The image processing program mainly uses H.264 encoding standard, achieved on the DSP side of the compressed video data stream, in the ARM to achieve control of the device and the input and output of the data control. ARM end T1925T processor based on ARM core, is the core of multimedia application platform. Its tasks are: to open the device, video data read the video file according to the receiving ability of DSP end and sends the video data to the DSP terminal and sends control information to the DSP side, the video data is processed at DSP after receiving the result after processing and output, shows the flow chart of the ARM side.

The end of the advantages of DSP can efficiently handle large amounts of data, so the video data compression processing on the DSP client implementation. According to the H.264 encoding principle, mainly based on the discrete cosine transform, quantization and inverse quantization module, the scanning module, motion estimation, motion compensation prediction module and variable length encoding module, For H.264, the encoded image is divided into three categories, namely I frame, P frame, B frame. I frame using intra-frame coding, P frame and B frame image using inter-coding[2].

In the ARM side and DSP side, respectively, to achieve their respective functions, we must achieve the communication between the two and dual-core program integration. This is mainly through the DSP Gateway under the MailBox mechanism to achieve, constitute the following.
  a. DSP task defined as TID, command and TID sent together.
  b. IPBUFS is used to transfer data between blocks of ARM and DSP.
  c. IPBUFS is managed by each processor, only when the IPBUFS data transmission, IPBUFS management authority will be transferred.

The program is mainly the ARM side to send data to the DSP operation, the DSP side processing, from the DSP device to receive the data returned.

Abrasive Recognition Method

The model is LT-191×18 narrow strip line light source and model JAICV-A1 CCD industrial camera to collect oil samples in the abrasive grain image. In order to improve the accuracy of abrasive grain identification, it is necessary to establish a sample library as much as possible, to do the rotation of the basic type of the sample and to transform the resolution of different resolutions, because there are various situations in the appearance and size of the abrasive grains in the oil sample.

By Gaussian pyramid and Gabor pyramid at different scales, first get nine brightness features, 36 color features and 36 orientation features. According to the 81 features obtained, 42 feature maps are obtained by calculating the central perimeter difference between the central fine scale c and the peripheral roughness s, including six luminance feature maps, 12 color features and 24 orientation features, We use the local special strategy to get the I’、C’ and O’ characteristic graphs, which can make the region more prominent and bright.

The selection of multivariable statistical units depends on the experimental and experimental conditions. The experiment of 4×4, 8×8 and 16×16 size is carried out on the Hotelling T² statistical method. The Haar wavelet basis is used to decompose the image, The coefficient is L = [-0.7071,0.7071] and the low-pass decomposition coefficient is H = [-0.7071,0.7071]. Wavelet transform is performed for each 2×2 wavelet processing unit, and an approximation coefficient and
three detail coefficients are obtained. \([A1, D1, D2, D3]^T\) are taken as wavelet texture features. A 256×256 grayscale image \(f(x, y)\) can be decomposed into 64×64 multivariate statistical units. Statistical analysis of the four wavelet processing units within a statistical unit results in a \(T^2\) value, that is, a 256×256 gray scale image can be 64×64 \(T^2\) statistic, which by the Hotelling \(T^2\) method image to reflect the abrasive particles Shape, highlight abrasive grain area and suppress non-regional[3] [4].

The support vector machine is based on the principle of structural risk minimization, that is, the instruction set \(S = \{f(x, y), w \in \Omega\}\) is decomposed into the function subsets \(S_1 \alpha S_2 \alpha ... \alpha S_n\alpha S\), Let each subset be organized according to the size of the VC dimension, that is, \(h_1 < h_2 < ... < h_n < ...\). After obtaining the empirical risk and confidence range of the subset, the minimum actual risk is achieved. The support vector machine constructs the optimal classification super planar through the sample in the original space or in the high-dimensional feature space, separating the given samples belonging to two different categories, and constructing the hyperplane based on the distance between the two types of samples and the hyperplane. The structure of the support vector machine is shown in Figure 1 below.

![Figure 1. Support vector machine structure.](image)

According to the Karush-Kuhm-Tucker supplemental condition, the optimal solution must be satisfied

\[
a_j \{y_i [(w \times x_i) + b] - 1 + \xi_i\} = 0, i = 1, \ldots, 1
\]

The Lagrangian function of the linear problem and the optimal classification discriminant function are expressed as

\[
L(w, b, a) = \sum_{i=1}^{L} 1 - \frac{1}{2} \sum_{i=1}^{L} a_i y_i y_j K(x_i, x_j)
\]

\[
F(x) = \text{sign} \{\sum_{i=1}^{m} y_i a_i K(x, x_i) + b\}
\]

Where \(b = y_i w \times x_i, i = 1, \ldots, m, n\) represents the number of vector machines. Thus, only a part of all \(a_i\) is not zero, and these samples are called support vectors, that is, the points that correspond to the satisfying points, that is, the nearest point to the optimal classification super planar.

\[
y_i \{(w \times x) + b\} = 1 - \xi_i
\]

The support vector machine uses different kernel functions \(k(x, x_i)\) to form different algorithms, using radial basis functions:

\[
K(x, x_i) = \exp \{- \frac{|x - x_i|^2}{\delta^2}\} = \Phi(x_i) \Phi(x_i)
\]

The abrasive grains in the oil sample are strongly reflective metal surfaces, which belong to the multi-class identification. For this reason, the classifier is required to expand to many classifiers. There are many kinds of expansion methods. One-to-one method is used to select two types of features.

The training process is as follows.

a. Given the \(c\) training samples of the two characteristics, the grain size classification vector of the oil sample is extracted as the classification basis.

b. Using the eigenvector of the above samples to carry out linear inner product support vector training to determine the linear recognition model function;

c. Using the eigenvector of the above samples, kernel function inner product support vector machine training is carried out to determine the nonlinear recognition model function.

Identification phase algorithm:
a. For a given sample of oil samples to be identified, extract the abrasive grain eigenvector.
b. If \( f(M) > \tau \) is used to determine the type of the sample to be identified, \( \tau \) is the threshold of the classification obtained by training, and if \( f(M) \) is the fitness function of the model, \( f(M) > \tau \) then go to step 3.
c. The feature vector \( M \) of the sample to be identified is substituted into the model function of the nonlinear classification support vector machine, and \( f_{\text{max}}(M) \) is classified into the corresponding defect class.

In the experiment, the parameters of the SVM are set to \( C = [2^6, 2^7, 2^8, \ldots, 2^{12}], \gamma = [2^{-4}, 2^{-3}, \ldots, 2^2] \), and the parameters of the support vector machine are given by using the one-to-many classification method. The kernel function uses the RBF function and the parameters \( C \) and \( \gamma \) are obtained by the cross validation accuracy, and then select the highest cross-validation of a set of parameters for training and testing[4] [5].

The Conclusion

To carry out the research of oil monitoring theory, realize the real-time and integration of monitoring, analysis and status judgment, and establish a network-based intelligent monitoring system for oil on-line monitoring. The DSP + ARM dual-core processor with DaVinci technology is used as the core Da Vinci Framework and H.264 algorithm components to build a high quality, low cost SIP-based streaming media transmission system, the oil-like abrasive image color characteristics of the study, developed a support vector machine, recognition accuracy are It is ideal to meet the requirement of on-line oil monitoring to monitor the visible iron spectrometer in the opaque lubricating oil. The experiment shows that the classification effect of the abrasive grains in the oil is very satisfactory, the average classification accuracy is 97.22%, the impact of more serious reflection of the environment can reach 94.11% recognition rate.

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References

[1] Roylance B. Ferrography-then and now [J]. Tribology International, 2005, 38 (10): 857-862
[2] Li Bo, Feng Song, Mao Junhong. Online image visual ferroelectric LED array reflection light source design and implementation [D]. Xi'an: Xi'an Jiaotong University Journal 2014 (10).48
[3] Xalo H.L. The development of ferrography in China-some personal reflections [J]. Tribology International, 2005, 38: 904-907.
[4] Dong Guangneng, Mao Junhong, Xie Youbai. On the establishment of online image visual iron monitoring standards [J], equipment management and maintenance. 2011
[5] Lu Xiao-jun, Xie You-bai, Zheng Nanning, Liu Yue-hu. Experimental study of image visual online ferrography [J], Journal of Tribology 2006 (6): 580-584.