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Research on Detection Method of Sheet Surface Defects Based on Machine Vision

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Abstract. The paper is based on machine vision technology to study the detection of sh eet surface defects, designs the hardware system and software processing flow of onlin e detection, introduces processing methods such as image preprocessing, image segme ntation and target extraction, and processes the defect images accordingly. Use C# soft ware to design the human-computer interaction interface and on-line debugging and on -line detection for the online detection of sheet defects. The experimental results show that the detection method is feasible, the false detection rate is low, and it can be well a pplied to the online detection of wood automatic production process.

1. Introduction

With the development of the national economy and society, my country's timber consumption has incr eased year by year, becoming the world's second largest timber consumption country. my country's tot al forest stock is less than 3% of the world's total, and a large amount of timber needs to be imported a nd processed every year. Wood processing is gradually developing in the direction of mechanization, a utomation and scale. Due to the production environment, natural conditions and other factors, there are knots, corrosion, worm eyes, cracks and other defects on the surface or inside of the wood, which grea tly affects the utilization rate of wood boards. The utilization rate of wood in China is about 60%, whic h is comparable to that of the world. The utilization rate of more than 90% in developed countries vari es greatly. The use of automated production and automated detection technology can effectively impro ve production efficiency and wood utilization. If it can increase by one percentage point, my country w ill save 750,000 m^3 of wood every year. Therefore, wood defect detection technology in the automated production process has become an important part of the wood processing process. The log processing process, the sorting and grading of the boards mainly rely on artificial vision and experience, and the e valuation is based on the texture structure, color and lustre of the boards. Due to the different types and sizes of defects of the sheet, and the different working environment and work intensity of human eyes, it is easy to cause missed inspections and wrong inspections. Moreover, the efficiency of manual detec tion is not high, which causes a lot of waste of human and financial resources and wood resources. At present, the inspection of sheet metal processing mainly adopts manual inspection, mechanical inspecti on, radiographic inspection, ultrasonic inspection and machine vision inspection. Manual detection has disadvantages such as low efficiency, high false detection rate and strong interference. Mechanical tes ting is usually contact testing, which has disadvantages such as limited detection range, low efficiency, and possible damage to the plate. Although radiographic testing can improve efficiency and accuracy, it has disadvantages such as complex methods and high costs. Ultrasonic detection is also a contact det ection, mainly based on the attenuation and scattering signals of the ultrasonic wave in the medium pro pagation process. However, this detection still has some technical problems that need to be solved, and it is not suitable for large-scale online detection [1]. At present, the most research applications are the application of digital image processing technology, computer vision technology, BP neural network tec hnology to wood defect detection, combining fractal theory, wavelet analysis, pattern recognition and other technologies to study image enhancement of wood surface defects, Texture segmentation, feature extraction, pattern recognition and other issues. Based on the defect types and characteristics of raw pi ne imported from Canada in the Putin Wood Processing Zone and the production line speed requireme nts of the automated log processing and production process, the author designed the hardware structure of visual inspection, selected camera parameters and light source categories, and designed software pr ocessing procedures and software for the defect types Realize, and perform image extraction and defec t feature extraction.

2. System solution

In a machine vision system, the pros and cons of light source and camera selection are the key to direct ly determining the success of the machine vision system. In two-dimensional image processing, genera lly the image taken by the camera is first transformed into a grayscale image, and the required data is o btained after further processing. However, the Gray-scale image of the sheet surface is very susceptible to the color change of the sheet pattern, and sometimes it cannot effectively reflect the defect informat ion such as the pits or convex nodes on the sheet surface, which makes it difficult to extract the charact eristics of these defects. Therefore, the Locator 2380 integrated 3D smart camera that can obtain grays cale images and height maps is selected in the machine vision system for sheet defect recognition. The camera is produced by Canadian LMI company. It uses a monochromatic laser to obtain high-precision brightness images with a maximum Z-direction resolution of 0.092mm.

The visual system architecture of sheet defect detection with 3D smart camera is shown in Figure 1. The camera is fixed horizontally directly above the plate, and the plate is kept flat and moved relative to the camera under the action of the driving roller and the pressure roller. The pressure roller is equipp ed with an incremental encoder whose output signal is used as the enable signal for camera scanning. When the plate moves, the pulse signal of the encoder triggers the camera to emit a monochromatic las er, which irradiates the plate to form reflected light into the camera lens, and the camera forms an imag e of the plate according to the different characteristics of the reflected light. Another function of the en coder is to record the length of the camera sweep, so that the image obtained by the camera is coordina ted with the actual object size. The Locator smart camera transmits the scanned image to the computer for image processing through the Ethernet interface. For the convenience of programming, the image p rocessing program uses the machine vision algorithm package HALCON developed by the German M Tech company. HALCON has a widely used machine vision integrated development environment, and its flexible architecture facilitates the rapid development of machine vision systems [2].

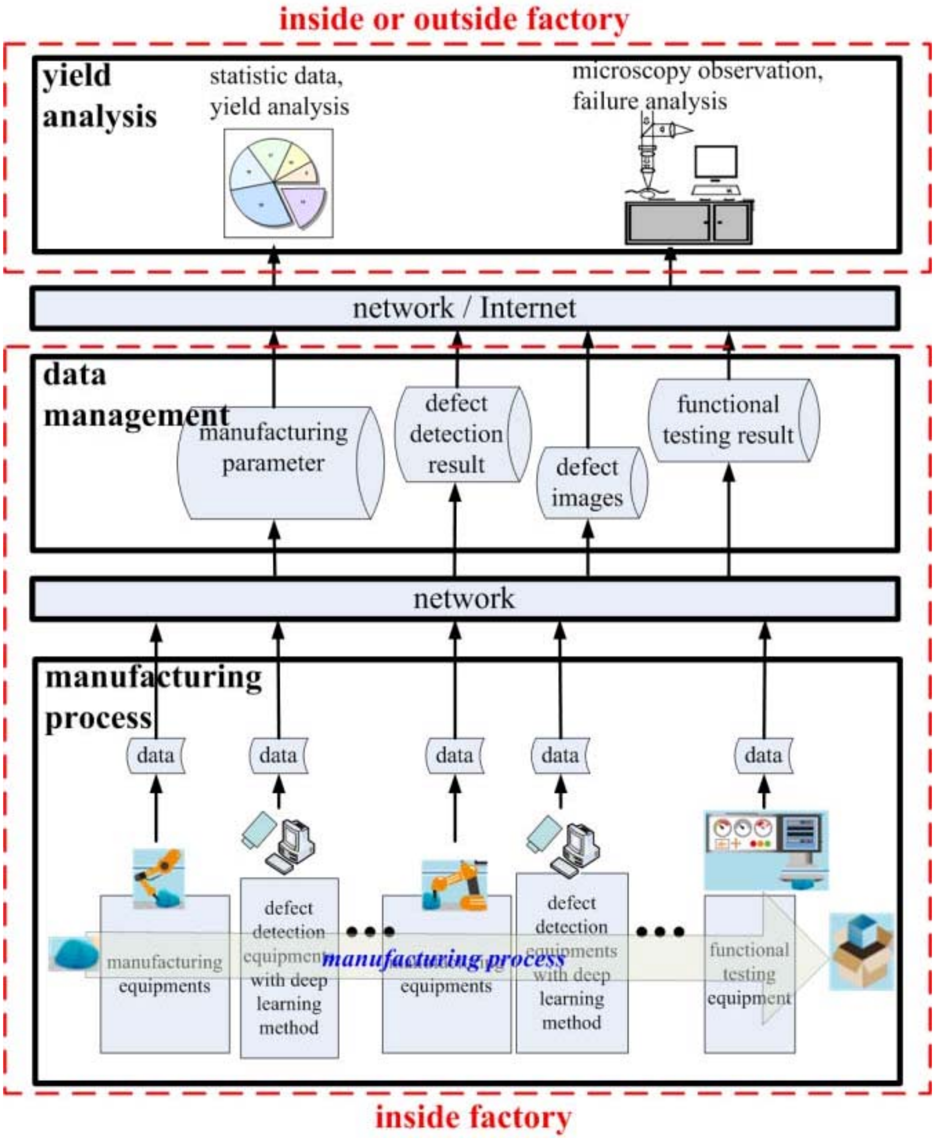

Figure 1. System architecture.

2.1. *CCD camera*

CCD is a semiconductor imaging device, which has the advantages of high sensitivity, anti-glare, small distortion, small size, long life, and anti-vibration. This system uses a domestic MTV-1881EX black-and-white camera. Its working method is to focus the image of the object on the CCD chip through the lens. The CCD accumulates a corresponding proportion of charge according to the intensity of light, and the charge accumulated by each pixel Under the control of the video sequence, it is moved out point by point, filtered and amplified by the video capture card, and A/D converted to form a video signal output.

2.2. *Frame grabber*

This system uses Dashing PCI-XR video capture card, with high-quality video capture performance, high-speed PCI bus, the capture frequency is 3D frames/sec, the display screen is smooth and uninterrupted; the display resolution is 640X480. Dynamically captured images are saved as static images, and multiple save formats such as BMP, JPG, TIP, TGA, etc. are provided. Its working principle is shown in Figure 2:

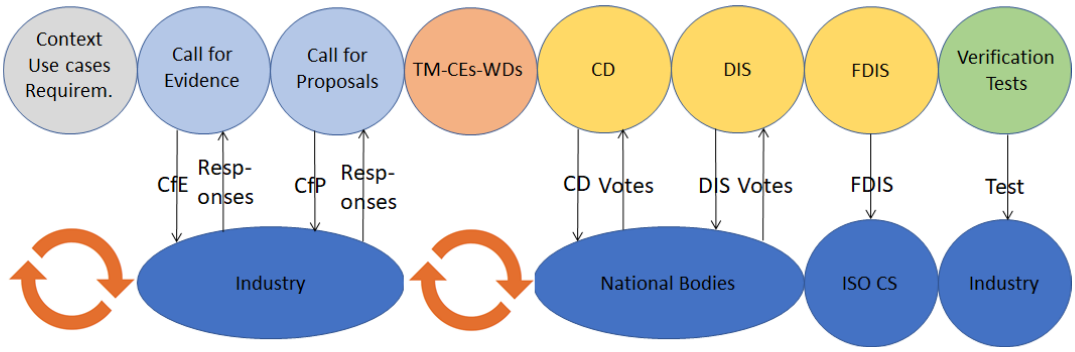

Figure 2. Working principle of the VIDEO-PCI-XR image acquisition film.

The four-channel composite video input is multi-channel switch. The software selects one of them a s the current input, and outputs it to A/D for analogy/digital conversion. After various image processin g, the digitized image signal is transmitted to the VAG card for display or Computer memory storage. Since the two surfaces of the board need to be detected, two video inputs are required on the hardware, and each channel collects images of a different surface. The sampling frequency is adjustable within a certain range to meet the needs of different occasions.

2.2.1. Video input signal and sampling frequency. The image signal output by the video equipment tha t conforms to the PAL standard (625 lines, 50 fields/sec) and NTSC standard (525 lines, 60 fields/sec) can be used as the input source of the video capture card. In general, video equipment such as cameras and video recorders meet the above standards. The sampling frequency is adjustable within a certain ra nge to meet the needs of different occasions.

2.2.2. Video input window and display window. The video input window refers to the digitized input i mage size. In PAL format, the maximum size of the input window is 768 X 576. The NTCS format is 6 4 X 480. The image display window refers to the size of the image displayed on the VAG monitor, and the maximum value cannot exceed the input image window. When the image display window is small er than the video input window, there are two methods that can be used. One method is to reduce the si ze of the video input window, that is, reset the start line, end line, start column, and end column. Match the video input window with the image display window. The processed result shows only a part of the entire input image. This method is called cropping. The other method is to reduce the size of the video input window by squeezing points and lines, that is, setting the reduction ratio coefficient according to the relative size of the video input window and the image display window, and the processed result sh ows all the reduced input Image, this method is called scaling down. You can also combine the two me thods to achieve the desired result [3].

2.3. *Software design*

The image processing algorithms in this subject are all simulated using the MATLAB programming la nguage. MATLAB provides a highly integrated one that integrates scientific computing, programming and visualization. In order to design practical and effective software, it is necessary to carry out suffici ent phased analysis and design in accordance with the theory of software engineering. Adopting modul ar structure design, its characteristics are: 1) Modifiable. Modifications to the inside of the module hav e no effect on the outside of the module; adding or deleting several modules does not affect the entire p rogram; 2) readability. The meaning and responsibility of each module are clear, and the interface relat ionship between the modules is clear, which is convenient for users and designers to maintain the syste m code; 3) Verification. Independent of other modules, the correctness of a module can be verified sep arately, which is convenient for debugging. The modular principle is adopted to make the software stru cture clear, easy to read, understand and maintain. In this system, the subroutines are designed accordi ng to the algorithm requirements.

Automatic detection of sheet surface defects is a new application of machine vision image processi ng technology. The inspection is carried out in the environment of the production line, the quality of th e collected images is low, and the signal-to-noise ratio is poor. The image processing process is the pro cess of noise removal, feature defect extraction and recognition. The software processing flow of the d efect image is shown in Figure 3. First, extract the target image from the collected image, remove the b ackground interference, obtain the target image to be processed, and perform a series of pre-processing on the target image to highlight the image features; then perform the feature extraction on the image, t hat is, a series of parameters to be detected According to its characteristics, find suitable methods to de scribe its characteristics; finally, analyse and save the results, and judge whether there are defects and defect types according to the test results of the parameters [4].

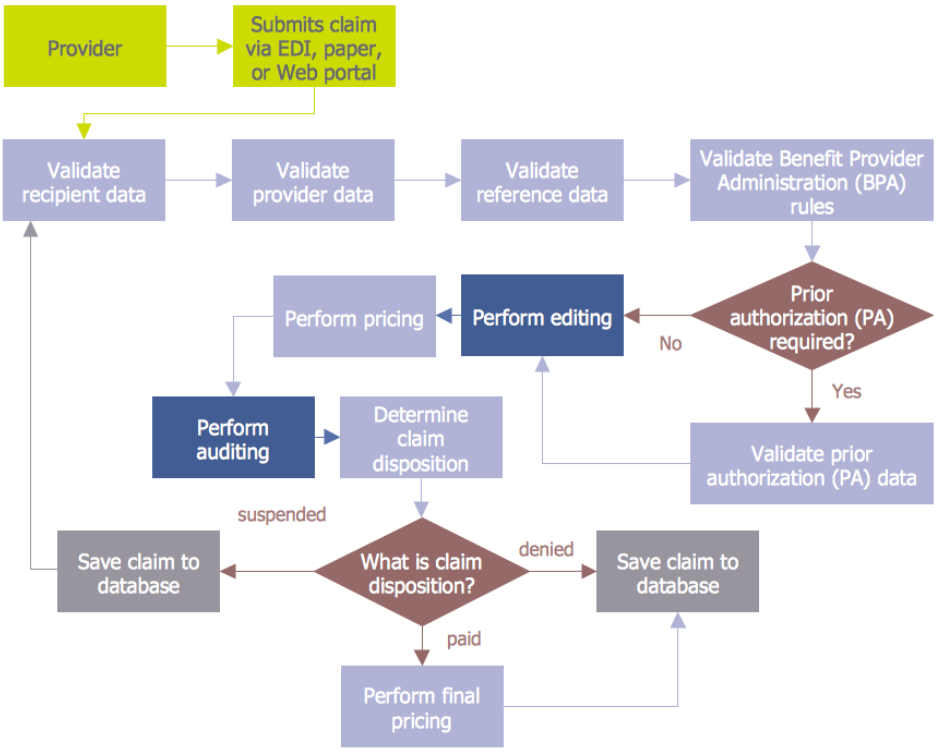

Figure 3. Software processing flow.

3. Surface defect image detection algorithm design

In order to accurately and timely obtain the current state of the image, it is necessary to continuously read the image information of the CCD camera system directly into the computer memory through the image capture card, and perform other subsequent processing in the computer memory, such as: image filtering, image measurement, and defects Detection and so on [5].

Because there is noise or other interference in the actual image, the background of the image is not the ideal pure Gray level. Therefore, when scanning the entire image pixel by pixel, the detected image information will also contain interference information, that is There are gross errors. Once a measurement value with gross errors is found, it should be removed from the measurement result. Suppose the measured true value is L_0, and a series of measured values are l_i, then the random error δ_i in the measurement column is

$$\delta_i = l_i - L_0 \tag{1}$$

The distribution density $f(\delta)$ of the normal distribution is:

$$f(\delta) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\delta/(2\sigma^2)} \tag{2}$$

In the formula, σ represents the standard deviation (or root mean square error); e represents the bas e of the natural logarithm, the value is 2.7182... It can be seen that the smaller the value of σ, the great er the absolute value of the exponent of σ, and the faster $f(\delta)$ decreases, that is, the curve becomes st eeper. The smaller the value of σ, the larger the value of the coefficient in front of σ, that is, the large r the ordinate corresponding to the error of zero G (σ=0), and the higher the curve. Conversely, the lar ger σ is, the slower the decrease of $f(\delta)$ will be, and the curve will be flat. At the same time, the ordin ate corresponding to the error of zero is also small, and the curve will be lower. The standard deviation J is also different, and K. In the equal precision measurement column, the standard deviation of a singl e measurement is calculated as follows:

$$\sigma = \sqrt{\frac{\delta_1^2 + \delta_2^2 + \ldots + \delta_n^2}{n}} = \sqrt{\frac{\sum_{i=1}^{n} \delta_i^2}{n}} = \sqrt{\frac{\sum_{i=1}^{n} v_i^2}{n-1}} = \sqrt{\frac{\sum_{i=1}^{n} (l_i - \overline{x})^2}{n-1}} \tag{3}$$

In the formula, n represents the number of measurements (should be sufficiently large); δ_i represen ts the difference between the measured value and the measured true value; l_i represents the measured v alue; v_i represents the residual error of the measured value (abbreviated as residual); $\overline{x}$ represents the measured value The average value of the value. In order to remove the gross errors from the scan, the 3 criterion is used to determine whether each detected data has errors. That is $|v_i| \succ 3\sigma$. If the above form ula is satisfied, it should be eliminated.

4. Experimental testing

We set the judgment thresholds of corners, scratches, knife marks and pits of the sheet with the specifi cation of D9.2*d4.02*1.2 and the sheet with the specification of D9.2*1.2 as shown in Table 1 and Ta ble 2 shown.

Table 1. Judgment Threshold of Sheet Metal Defects.

Type of defect	Drop corner		Scratches		Knife mark		Ma Hang	
	area	perimeter	area	perimeter	area	perimeter	area	perimeter
Value	36	17	53	31	384	98	31	14

Table 2. Judgment Threshold for Defects of Round Plate (Unit: Pixel).

Type of defect	Drop corner		Scratches		Knife mark		Ma Hang	
	area	perimeter	area	perimeter	area	perimeter	area	perimeter
Value	51	27	65	40	455	112	38	15

20 pieces of qualified products, 10 pieces of corners, 10 pieces of scratches, 10 pieces of cracks, 10 pieces of knife marks, which are manually detected with a specification of D9.2*d4.02*1.2 (D9*1.2) (D9*1.2) 10 pieces of pits and 10 pieces of sand holes, a total of 80 pieces of plates are mixed together, and put into the surface defect automatic detection system that has been initially developed to detect a nd classify defects. After repeated experiments, the data analysis results are recorded.

Analysing the above data, on the one hand, it can be seen that the hardware sorting mechanism of th e surface defect inspection system can correctly eliminate all the defects identified by the software insp ection system, indicating that the coordination and repeatability of the sheet sorting mechanism is relat ively reliable; On the one hand, it can be seen that the detection rate of dropped corners, pits and knife marks is relatively high, reaching 80%, the detection rate of scratches has reached 74%, and the detecti on rate of cracks is only 65%. It can be seen from the collected images of the cracked and scratched pla tes that are judged to be qualified products, the cracked plates are very deep due to the small defect sur face, and the current imaging system cannot fully display the defect information of the plates, so appro priate lighting should be redesigned Light source; and the reason for the misjudgement of scratches is t hat the defects on the surface of the sheet are relatively shallow, and the collected images are discontin uous lines or flakes. After image processing, they become intermittent short lines and dots, which mak e the defects the characteristic parameter is less than the threshold value of the corresponding defect ju dgment, which causes the misjudgement as a qualified product. Moreover, due to the limitations of the existing defect identification methods, the familiarity of the shape of cracks and scratches, and the ran domness of the defect location, the two types of defects can be distinguished There are difficulties [6]. In the detection results, these two kinds of defects are mixed with each other. Therefore, in addition to improving the image quality obtained, it is necessary to find a suitable image processing algorithm to i mprove the detection rate and recognition rate.

5. Conclusion

The wood-based panel surface defect detection system based on machine vision realizes the online det ection of large-format panels on the continuous press production line. The defect location is accurate. The defect detection results and the inspection time of a single panel meet the design requirements. Th e system can adjust parameters flexibly and conveniently according to the type and format of the man-made panels produced; the design is simple, the hardware equipment is easy to configure and maintain, and the software can be modified and re-developed according to the actual production needs of the ent erprise, providing technical support for popularization and application.

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