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Pipeline weld detection system based on machine vision

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***Abstract*—**To the pipeline welding defect detection, robot tracking weld reliably, the welds original image acquired by visual sensor need pretreatment to eliminate the impact of noise. A pipeline welding machine vision detection system proposed in this paper. With the help of Embedded Computer and takes full use of the traditional ultrasonic-testing device, FPGA, USB, electronic technology and wavelet transform signal processing， the system realizes data collection, save, display, analysis and processing. Using of neighborhood mean filter for smoothing, feature prominent method to segmentation image. Image after smooth will be the binarization processing. Then remove the small area noise with labeling method, get a clear image of the weld. The level of projection method to the recognition of weld image and determine the location of weld. The experiments show that the advantage of small, plug and play, stability, high rate, efficiency and reliability, the pretreatment method solute the prevailing situation of uneven illumination, and also reducing the size of the processing image, meeting the needs of the pipeline weld tracking real-time detection.

Keywords-Image processing; Object recognition; robot; computer vision

I. INTRODUCTION

The pipeline is an important tool for material handling. Modern industry, agriculture and daily life are inseparable from the pipeline. Pipeline construction site used for welding group. It is the field of construction in most cases, poor conditions. Butt ring welding part is the failure accident-prone position. Pipeline welding is the key technology need to be ensured in construction [1]. Detection robot crawling tubes to achieve tube-line inspection and maintenance. Fast and effective weld tracking is the key of the realization of tracking, testing automation [2]. Tube due to environmental conditions and human factors, with the changes in ambient light and position between the work piece and camera, interfere with CCD camera in the weld tracking process, quality of the frame image has change. Thus affecting the quality of image, position detection accuracy is not ideal. The main thesis of the paper is research pipeline inspection robot vision system. Using embedded computer to build portable detection equipment, USB interface used to solve the high-speed data acquisition in the data transfer rate. Image of the weld with computer make on the process such as the real-time collection, pre-processing, image segmentation, edge detection, identification. Getting accurate weld information, in the conditions of not need human intervention, robots recognize the pipeline welds successfully by arbitrary radius of the pipeline. And then obtain precise coordinates of the location of the weld for the follow-up quality of detection, processing and so on.

II. PIPELINE WELD DEFECT VISION SYSTEM

System are composed by such as the CCD camera, lighting, image acquisition card, mechanical devices, host computer (PC), ultrasonic probe, pipes, Structure of the system in Fig.1. In the process of establishment of the image sensor system, to reduce the ambient light on the impact of image quality, it can get clear and stable image by auxiliary lighting [3]. The visual system provides a structure of the laser light source and laser welding work on the project.

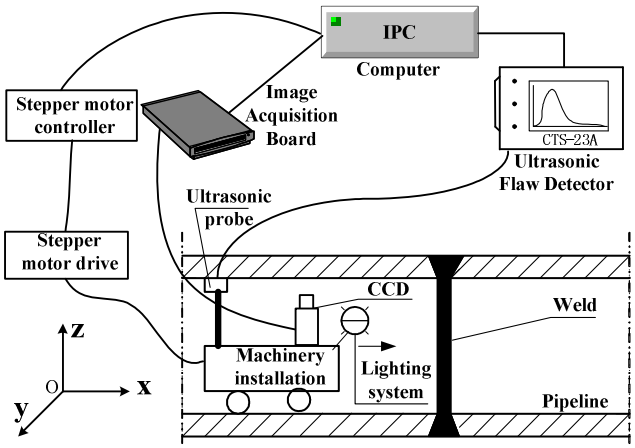

Figure1. Visual Inspection System

The course of their work: robot bring the ultrasonic probe, lighting and camera into the pipeline, the scene inside pipeline are intake by the CCD camera, then after image acquisition card and sent to the computer.

III. THE DESIGN OF EMBEDDED COMPUTER

A. Embedded computer hardware system

Embedded systems hardware platform is embedded 32-bit processor Intel® Strong ARM *SA-1110. The main function modules by the microprocessor and logic control, the system memory modules, human computer interaction modules, USB, network communication, power management and debug and download the OS interface. Software platform is using windows CE. The system shown in fig. 2 has the following functions and features:

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1) The processors using Intel® Strong ARM *SA-1110, the highest operating frequency to support 220MHz.

2) Flash memory 32M bytes to store user program, SDRAM memory 32M/64M byte options for the use of running WinCE.

3) Provides a RS232 serial port, LCD controller interface, a CF interface, support for the WinCE and CF card debugging, memory card, USB host controller, LAN card and other expansion board.

4) 8 general I/O ports, RTC, Watchdog and the internal clock, power management controller, interrupt controller, the restart controller.

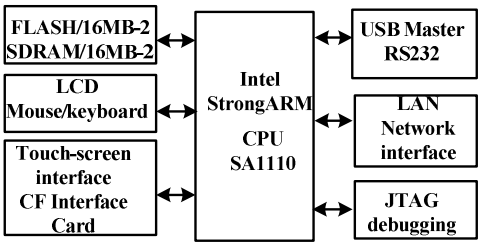


Figure 2. Embedded computer hardware system

B. Windows CE software platform

Platform Builder is a device tools for embedded systems development and customization based on the Windows CE operating system. The development processing is the basic platform to create, customize the platform and operating system to download image files to the target device. In the creation of a basic platform, mainly including the configuration of the platform, the creation of the operating system image, image transmission to equipment and debugging the target system. In the process of the custom platform there are major to develop their own OAL (OEM Adoption Layer), device drivers and guide the loading process, components, localization [3].

Guide loading procedure is used to download the platform which created in the development environment to the target device and to achieve the goal of monitoring and testing equipment. A platform made up of two parts: one from the core components of Windows CE, the other part comes from the BSP (Board Support Package) device drivers and configuration of the OAL. To complete a full course of the development have the following steps:

1) Creating a basic platform.

2) Download image files of operating system and guide the target device.

3) Using of kernel debugger.

4) Create user components and custom platform.

5) Output SDK.

C. USB host controller driver model and driver

USB driver of Windows CE is based on the external model. USB host controller driver involved in such as environment parameter setting of platform builder development environment, the corresponding amendments to documents and the driver preparation two major parts [4]. MDD and small PDD depended on platform. OHC interface on the hardware specifications clearly define the hardware performance. PDD layer of most HCD module only used in memory positioning host controller hardware address, and the hardware address and a shared memory area pointer are given to the MDD layer. However, compared with other internal device drivers, MDD and PDD layer of HCD module interaction between layers is more complicated. Must be generated registration key in the HKEY_LOCAL_MACHINE\ Drivers\ Builtin, to enable device management procedures load HCD module at the platform boot time. Equipment management procedures should also provide the corresponding interface function. Thus, despite the HCD interface module is not flow-driven model, PDD layer still need to include some additional DDSI function, such as Ohcdpdd_Open and Ohcdpdd_IoControl. The advantages of the way are that equipment management procedures call the Ohcdpdd_Init function of HCD. The function in turn, let HCD modules call required MDD function. Layer interaction between PDD and MDD of OHCD in initialization process shown in Fig. 3.

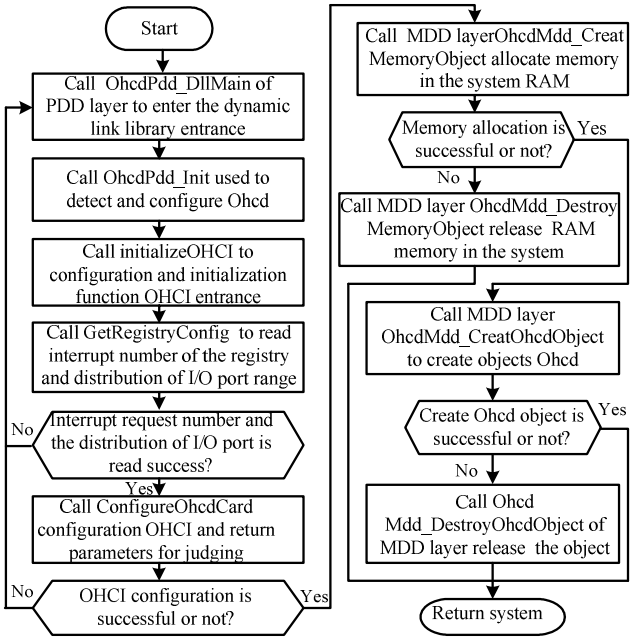


Figure3. OHCI initialization flow chart

The following a brief description for the registration key of HCD module.

(HKEY_LOCAL_MACHINE\Drivers\Builtin\OHCI)

"prefix"= "HCD" "Dll"= "ohci.dll"

"Index"=dword:1 "Order"= dword:1

PDD layer must call MDD layer function as follows:

OhcdMdd_CreateMemoryObject

OhcdMdd_DestoryMemoryObject

OhcdMdd_CreatOhcdObject

OhcdMdd_DestroyOhcdObject

OhcdMdd_PowerUp

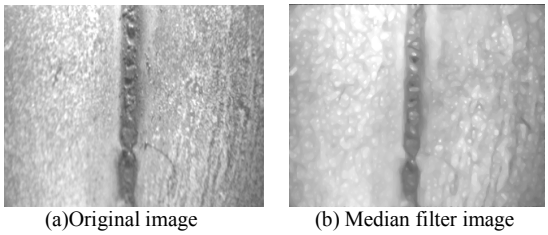
OhcdMdd_PowerDown
PDD layer provide DDSI function as follows:
OhcdPdd_CheckConfigPower
OhcdPdd_Open OhcdPdd_Close
OhcdPdd_PowerDown OhcdPdd_PowerUp
OhcdPdd_Deinit OhcdPdd_DllMain
OhcdPdd_Init OhcdPdd_Read
OhcdPdd_Write OhcdPdd_Seek
OhcdPdd_IoControl

IV. WELD IMAGE ANALYSIS AND PROCESSING

CCD camera acquisition weld image, converted by the A/D of image board into computer memory. And then use a variety of image processing methods for image data processing. Image processing requirements of a short time, can accurately extract weld information and accurately detect the location of weld, realize real-time automatic detection of weld.

A. The image smoothing

The image contains noise, if the direct binary, in the binary image still exist in these noise, this is difficult to the follow-up weld identification. Weld may be made to identify the error. As a result, the original image need filter to remove noise [5]. Taking into account the characteristics of the weld image, the better results median filtering is used. It is used to eliminate noise and preserve image details situation. The pixel larger difference surrounding pixels gray value to get close to the around pixel value so that can eliminate isolated noise point. Effect after the median filtering 4 times is already good. And generally median filter overcome the edge drift impact of the other filter. As shown in Fig. 4.



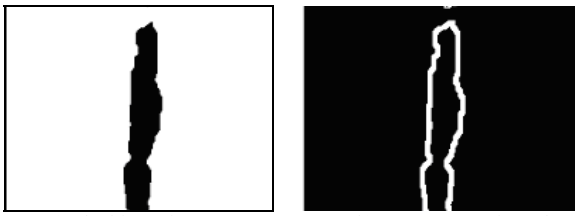
(a)Original image (b) Median filter image

Figure4. Weld median filter image

B. Weld image segmentation

As the weld image obtained in the dark internal channel, the limitations of light and characteristics of the CCD camera, there may be non-linear distribution of light intensity in weld image. The overall picture is bright in the middle, surrounded by dark, so that affected the image of the weld edge detection and the deal of segmentation, it is difficult to identify. Getting gray image in light of this disparity, binary image is not expected with histogram analysis of the above method to determine the threshold.

As the tube uneven light intensity, dark on the both sides, bight in the middle. Feature prominent method is used weld image segmentation. The method is not to deal with around the image. That is, remove the image up and down about of the four sides. Only dealing with a large piece of the middle region solve the problem of uneven illumination. This method reduces the scope of the camera's perspective. The image shooting speed are 30 frames/s, and will not take a leak region. Therefore, the entire system does not affect the efficiency. Under the circumstances, Images are removed from both sides of 45 pixels, up and down on both sides of the 10 pixel in image processing. Removed the pixel image and then after histogram analysis determine the threshold easily. Because at this time histogram showed two peaks, histogram analysis to be the threshold T=160.



(a) The binary image (b) Image extracting edge

Figure5. Weld image threshold and extracting edge

Fig. 5 is the weld image that the feature prominent method threshold segmentation and then edge detection. Threshold segmentation of the binary image after removing a number of pixels of four sides is shown in Fig. 5(a). Fig. 5(b) is the image edge using LOG extraction algorithm. The effect comparing with the largest variance method can see the obvious that weld's features more prominent, complete, almost all the noise removed. It is very good results for the identification of weld. As a result of this approach in dealing with the images will be removed from all four sides of some of the pixels. This is not only dealt with reducing the size of each image, reducing the amount of data, saving time, but also solves the problem of uneven illumination, reduces the image of the surrounding noise. So that the goal of a more prominent features to identify beneficial.

C. Weld Target Recognition

Sometimes there are rough surface within the pipeline led to a lot of interference the times of identification, the uneven illumination, motion blur. It is not easy for objects edge split. Therefore, the contrast between weld and other objects is too small. To solve these problems, using projection methods identify object [6-7]. It is particularly well suited to the strip object recognition. The specific method for weld identification is as follows: From top to bottom, left to right scanning the projection image, weld place after a certain projection is higher than other places and first detected off. Based on the above principle, the binary image of the weld after the threshold partition to do a level projection, Fig. 6 is the level projection image that image partitions use several threshold segmentation methods.

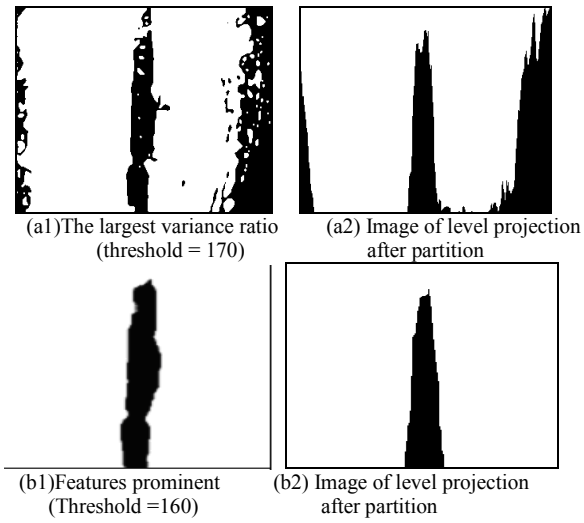


Figure6. Level projection map of the weld

The projection image that the partition with the largest variance ratio shown in Fig. 6(a2). This method can not solve the uneven distribution of light completely. From the projection image, it can be seen that the dark on both sides of images is not resolved. Fig. 6(b2) is the projection image that the partition with features prominent method. It can be seen completely remove the noise and interference. Only the projection Weld runs through the middle of the image, so it is easy to identify them.

V. CONCLUSIONS

Weld tracking in the case of non-welding need carried out with appropriate auxiliary light source. Based on embedded computers, USB interface for data transmission consisting of ultrasonic detection of intelligent machine. Avoid the glare of the surrounding environment such as noise to interfere with the track process, use the appropriate resolution of the camera and video capture card. Weld image will be reliably separated from the noise after image pretreatment and get a clear image of the weld. In the case of the weld on the brink of partition not easy to carry out, studying welding identify issues use of the level projection and get the better results. Weld image pretreatment and extract the information needed a short time. It has been shown that USB bus interface meet the high-speed data transmission needs of ultrasonic testing, using FPGA technology simplifies the design, have a hot-swappable, and reducing the cost of hardware and software. And meet the pipeline welding machine vision testing position requirements.

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