Study on Online Monitor System for Surface Quality of Rolling Rail Based on Machine Vision

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Abstract. In view of quality control process of the heavy rail on universal rolling line, based on method of machine vision, a system can be used to monitor surface defect of hot rolled heavy rail has been developed and it's configurations of hardware and software are introduced in this paper. This system adopted gigabit Ethernet cable for data communication to ensure stability and reliability of the transmission system for super large data, and high speed linear CCD camera used to get effective reliable heavy rail surface image, and image resolution can reach 0.5 mm/pixel, defect size of hot rail larger than 5 mm can be collected and displayed. In the system, with the aid of intelligent discriminant algorithm to recognize the surface defects of heavy rail, it is successful to implement real-time monitoring for surface quality and to reduce leave out and mistake rate of the hot rolled heavy rail.

Keywords: Machine Vision · Hot Rolled Rail · Online Supervision · Quality Control

1 Introduction

It is very important for quality control if the defects of rolling rail surface can be detected and controlled. Usually, two different stage at present can be dived during rolled process that is named hot detection and cold detection respectively. Cold detection is carried after rail straightened and hot detection is carried during rolling when the rail is passing the place where sensor is located or person is standing. That is say the methods of rail quality detection comprise human detection and instruction monitor, which have devices based on Electric Eddy Current surface defect detection, flatness detection, laser cross-section dimension measurement, the ultrasonic internal defect measurement of rail and so on. After the detected rail passing through the position where the device placed, the detected data is send to computers and be handled to check the qualities of every parameters of rail contour and internal and rail surface, and the rail quality grade can be decided thereof [1].

Hot rail is being rolled rail with high temperature, which surface is red and it runs in high speed so that it's quality is hard to monitored now. Hot rolled rail can be canceled from process if it's defects are found in time, then the defect rail can be dealt immediately and much lost can be saved meanwhile. During finish rail process, manual inspection and testing are main method for rail surface quality monitor yet [2]. In this inspection,

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strong light is shined on the surface of inspected hot rail through a gap in plate, and the defected rail can be found according to the reflected light beam. The number of rolling rail is be recorded if defection is found on the rail surface, then further analysis and detection is carried and to decide it's rolling process canceled or continued after the rail is send to cooling bed. So the work is hard for people to gauge because of high temperature and heavy dust in the factory environment, usually only ten percent rolled rail can be monitored in production and only the part of head and end of the rolled rail can be inspected every time. Besides the above disadvantages, person safety, surface quality control unavailable are also serious problems and should be solved.

2 Vision Monitor System of Hot Rolled Rail

Vision monitor system of hot rolled rail that are consisted of hardware and software can take place of person to finish the task of detecting the surface quality of rolling rail. The configuration of hardware system included vision sample with high speed, data transforming by gigabit network, and data processing. All of devices of three parts in field should be selected carefully to satisfy the performance demanded and protected from the high temperature. Server computer is fixed in controlling room and received vision data online when CCD is working.

Software of vision monitor system is developed based on C/S pattern to assure the requirement of data in liquidity, security and real-time, and the C/S pattern is helpful to realize the data sharing in the LAN network of the rail beam factory, in which technicians at all levels can access the vision monitor data in real time or offline by authorization so as to improve the utilization of data and make information mobility better.

2.1 Hardware System of Vision Monitor

In earlier stage, these are four sits of device of vision sampling which are installed in location of output of rail rollers respectively, but the hardware framework and the software architecture should be expanded easily to adapt dozens of device of vision sampling if monitor system need in future. So it is necessary to consider that interfaces for data transmitting and connection are abundant and capable of operating stability requirements.

The four image collectors named CCD are installed on both sides of the roller lane after the UF finish milling, directly connected to the central server of the CP8 control room through the Gigabit network cable, transmitting the digital image to the central server at high speed. The central server is connected to the remote terminal of the hot monitoring room via optical fiber, ensuring the quality and speed of the image transmission.

The central computer in the vision monitor system is a high-performance workstation, which mainly provides image processing algorithms and data services, which can be capable of large and complex image processing tasks. The central server is also the data center of the whole vision monitor system, providing data storage, backup and service functions etc.

Monitoring position and camera layout of the rail surface is show as Fig. 1.

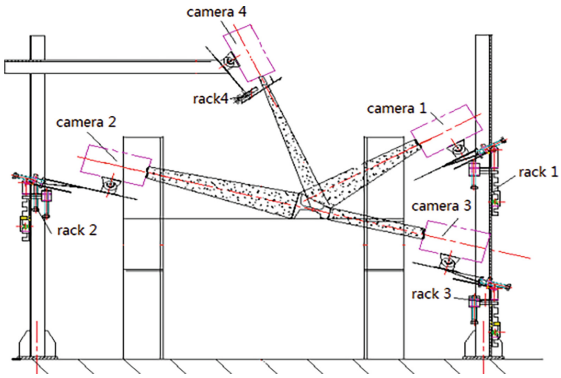

Fig. 1. Layout of cameras in site

The rail surface is a multi-plane, multi-curved complex surface. When the rolling rail passes through the detection cameras in field at a certain speed, the image data of different rail surfaces is obtained by sampling units composed of a line array CCD and a purge device for data acquisition. In this system, four sets of discrete data collection units were designed, as showed in Fig. 1, installed on adjustable supports to assure cameras can scan on the rail surfaces, and conducted temperature control with water cold system to protect the image acquisition device. Considering the rail surface fluctuations and four cameras photo-graphing the rail surface simultaneously, white light beam is projected to the surface of the rail to increase the brightness of the camera scanning site and the clarity of the obtained image. As shown in Fig. 1, the camera 1–4 shoots the tread surface, bottom surface, upside waist surface and lower part of upside waist surface of the rolling rail respectively. Schematic diagram of the camera mounting is show in Fig. 1.

2.2 Software Architecture of Vision Monitor System

The main functions of the software system include: high-speed image data collecting and transmission synchronizing with the rail rolling process to ensure high resolution image can be obtained by detectors in real-time, image preprocessing algorithm, massive image data management and maintenance, friendly human-computer interface, intelligent rolling rail defect recognition algorithm etc.

After the software system is started, the relevant hardware will be tested automatically, and then the operation mode and the operation state of the basic function module of the system are initialized using the parameters of the previous operation. The module of human-computer interface makes the user easy to modify the system working mode and operating parameters, and these mode and parameters can be saved in the system status management module. The system task management module determines the task and working mode of the basic function module according to the system working mode and the basic function module. The basic function module is responsible to coordinates the work of various functions and modules, so that all parts of the software and hardware can run in parallel or time-sharing to realize the security monitoring and communicating in high speed and quality, and with high flexibility.

The software system is divided into monitoring module and data server module. The monitoring module is capable of the human-computer interaction, which is mainly responsible for the data collection, analysis, storage and management of the steel rail images. The monitoring module is also a client of the database server that reads the relevant information from the database and stores the data into the database.

The monitoring platform is developed by C++ combines COM technology, XML technology and ActiveX technology to directly manage the underlying hardware and be in charge of communication. Therefore, the monitoring module can be run with a higher efficiency, and can meet the needs of real-time detection. Meanwhile, the embedded image processing engine can quickly analyze and process the image focus area (such as the defect area of the rolling rail), obtain relevant data and provide it to defect recognition module of the system [3].

The function of the monitoring modules in the software system include: user management submodule, camera management submodule, camera acquisition submodule, image transmission submodule, image display submodule, image processing submodule, image playback submodule, control submodule, recognition and learning submodule, and data management engine submodule. The inter-logical relationship between these submodules is shown in Fig. 2.

The system function module is mainly based on the data engine module that is centered by other submodules of the monitor system when it is running. In terms of data mobility, the module mode is adopted by the software system to ensure the image data collection, data transmission, data processing and image display, to avoid the cross and damage of data flow and improving the data utilization efficiency. On the other hand, the data engine module of the monitoring software system is the most important running environment and comprised part, and the whole software system is launched around the operability of the monitoring module. At the same time, the extendibility and practicability of the system is also considered in full.

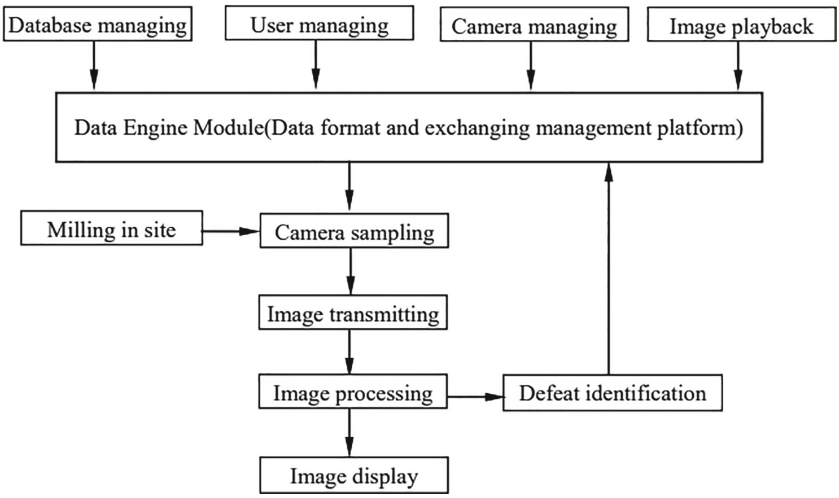

Fig. 2. Relationship among models of software

In terms of the overall design of the software system, the needs of the network client are also taken into account, that is, the relevant technicians can browse and obtain the data through the network to improve the utilization rate of obtained information of the rolled rail. On the user interface, the acquired rail image can be the slowly displayed and playback if need, and these function of the monitor system allows the observer to clearly find out defects anywhere on the track by the rail surface image.

3 Monitoring Cases

After the monitoring system was put into use, the system has successfully monitored the rail rolling defects for many times, significantly reducing the scrap rate of the universal rail rolling line. For example, in the area of about 75 m of the rail, the rail appears continuous sunken interval about 3 m. When the sunken rail passes through the UF finish rolling, the monitor system detects out the defects immediately, and send a alarm when the defect of the rolling rail continuity is found, at the same time, the main operation process immediately stops the running and returns back all the rails entered the milling line [4, 5]. Because the defects were found and stopped in time, the number of scrap rails was controlled lower than five percent. The monitoring result image is shown in Fig. 3.

Due to the many rail rolling defects monitored, they are no longer detailed in this paper, supported only by the 2 surface defects shown in Figs. 4 and 5.

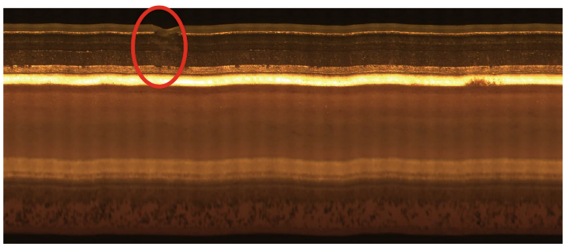

Fig. 3. Monitored Surface defect of hot rail (flake off)

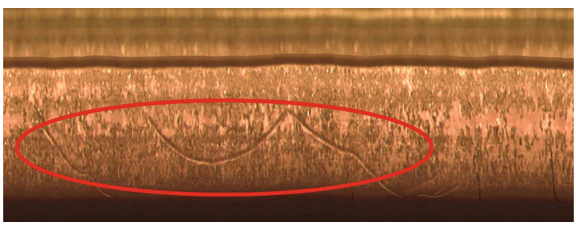

Fig. 4. Monitored Surface defect of hot rail (scraped slot)

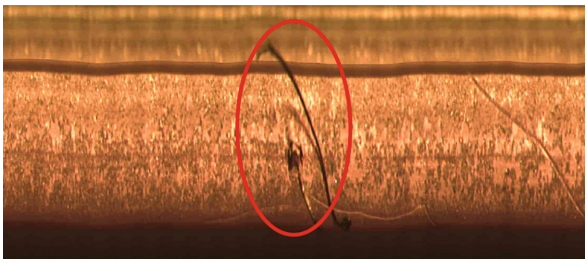

Fig. 5. Monitored Surface defect of hot rail (embedded wire)

4 Conclusion

The system has been proved by the operation in field nearly a year, that the visual monitoring system of hot rail surface defects can better adapt to the harsh environment in site. It also can stably and effectively obtain the rail surface images in the environment of high temperature, strong radiation, heavy dust and strong interference, and the obtained image is clear to discriminate the defect zone and the normal zone on rail remarkably, and the image meets the monitoring requirements. In system the obtained image of the rail different surface are taken from different direction angles by four cameras, avoiding the limitation that only one surface of the rail can being seen if person monitoring, realizing that the multiple sides of the rolling rail be monitored and observed simultaneously, which effectively improves the efficiency of hot rolled rail monitoring.

Although the hot rail pass speed is fast, because high speed line array CCD camera is adopts in the monitor system, the image of the rail surface is obtained effectively and reliably, and the image resolution can reach 0.5 mm per pixel, so defect images no more than 5mm can be clearly collected and displayed in time. In data transmission of the system, six class gigabit network lines are used for data communication, ensuring the stability and reliability of super-large data transmission.

The application of the vision monitor system greatly avoids the false inspection and reduce the rate of defect because of the hot steel rail surface quality, and makes each defect can be checked repeatedly and maintained permanently, which is conducive to the identification of small defects and early identification of all defects, thus the monitor system has a significance positive effect to guarantee the rolled rail quality.

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