Optik 125 (2014) 5803–5807

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

On-line conveyor belts inspection based on machine vision

Yanli Yang*, Changyun Miao, Xianguo Li, Xiuzhuang Mei

School of Electronics and Information Engineering, Tianjin Polytechnic University, No. 399 Binshuixi Road, Xiqing District, Tianjin 300387, China

ARTICLE INFO

Article history:
Received 25 October 2013
Accepted 30 May 2014

Keywords:
Machine vision
CCD camera
Conveyor belt
Longitudinal rip
Ethernet

ABSTRACT

Under the background that mining conveyor belts are prone to failure in operation, the on-line fault detection technique based on machine vision for conveyor belts is investigated. High-brightness linear light sources arranged to a vaulted shape provide light for a line-array CCD camera to capture high-quality belt images. A fast image segmentation algorithm is proposed to deal belt images on-line. The algorithm for detecting longitudinal rip and belt deviation which are serious threat to the mine safety production from binary belt images is presented. Then, an on-line visual belt inspection system is developed. The laboratory testing results testify the validity of the visual inspection system.

© 2014 Elsevier GmbH. All rights reserved.

1. Introduction

Mining operations require conveyor belts to move mined material such as coal from the working face over long distance to the processing plant. Mining conveyor belts are prone to failure in operation, such as longitudinal rip, deviation, and surface damage, which is a serious threat to safety production. When a conveyor failure occurs, it generally results in a stoppage of production, even causes belt break which can bring catastrophic damage to the transmission.

It has long been recognized that a belt condition monitoring system for early detection of unusual belts' tear and wear is desirable. At present, a variety of belt monitoring methods are developed, such as electromagnetic sensor detection method [1], radio frequency identification-based belt rip detection method [2], and the X-ray detection method [3]. However, current belt inspection methods have a limited fault detection capability. None of the method or apparatus has been used successfully in practice to detect surface damages of conveyor belts. Monitoring conveyor belts by the machine vision technique can improve the detection efficiency and precision, so it has attracted much attention. In this paper, the on-line belt monitoring technology based on machine vision is investigated to detect belt deviation and longitudinal rip of conveyor belts.

1.1. Machine vision and belt monitoring

Computer vision aims to duplicate the effect of human vision by electronically perceiving and understanding an image [4]. The machine vision technology has the characteristics of automation, intelligence, and accuracy. Intelligent visual monitoring has been widely used in the industrial production line of parts identification and location, such as intelligent transportation [5], wound tissue identification [6], railway maintenance [7], material defect detection on conveyor belt [8], and on-line analysis of ore components [9]. A visual monitoring system typically includes the module of image acquisition, image processing, and target recognition.

In fact, the technique of detecting conveyor belt failure by using the machine vision technology has aroused much concern. Ponsa et al. [10] developed a computer vision inspection system to detect defect of belts at a speed rate up to 2 m/s by using plane array camera to capture images. Using 30-million-pixel CCD area array camera and processing image signal by programming with C++ and Matlab, Zeng et al. [11] proposed a method to detect the coal belt tearing. In addition, Wei [12] researched the belt surface crack detection method by using a line-array CCD camera to collect conveyor belt images, but their research is still stay in the stage of laboratory research. Carnegie Mellon University researchers, using line scan cameras, developed a conveyor belt detection system which is applied to monitor the quality of belt splices, such as mechanical splice detection, vulcanized splice detection, and other type of splice detection [13].

The on-line belt condition monitoring technique based on machine vision is still at its preliminary stage. Taking into account the processing speed of images, the reliability of fault identification and the poor working conditions of conveyor belts, some of the

* Corresponding author. Tel.: +86 15522720085.
E-mail address: yyl070805@163.com (Y. Yang).

http://dx.doi.org/10.1016/j.ijleo.2014.07.070
0030-4026/© 2014 Elsevier GmbH. All rights reserved.

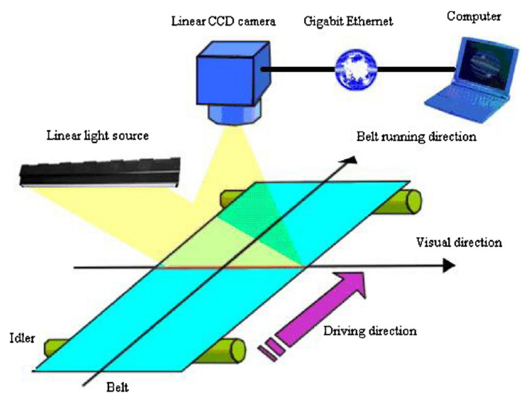

Fig. 1. Sketch map of the visual belt inspection system.

key technical issues have yet to be resolved to develop the visual belt monitoring system. These problems include the technology of high-quality image acquisition, high-speed image processing, fault identification, and so on.

The sketch map of the visual conveyor belt inspection system which consists of four modules, image acquisition, image transmission, image processing, and fault diagnosis is shown in Fig. 1. The main equipment of image acquisition is the line-array CCD camera. In order to improve the resolution on the belt width direction, several CCD cameras along the width direction of conveyor belts can be placed side by side. A large amount of image information will be produced for cameras working on-line. To monitor the belt of 1.2 m when running at speed of 6 m/s, for example, it will produce approximately 28 MB bitmap format image information each second if the resolution is set as 0.5 mm × 0.5 mm. In this paper, a gigabit network technology is utilized to transmit the image information to a computer in time. After images processing and faults detection, the running state of the belt, such as the deviation and longitudinal rip failure during operation, are identified.

The block diagram of detecting faults from belt images is presented in Fig. 2. First, the captured belt image is preprocessed to improve the image. Then, the belt edge is identified to crop the image. The improved belt image is segmented to obtain a binary image. Belt deviation feature is extracted from the binary image to identify the belt deviation. For rip detection, the binary image is firstly cropped to avoid some background noise. By extracting rip feature from the cropped image, belt longitudinal rips can be identified.

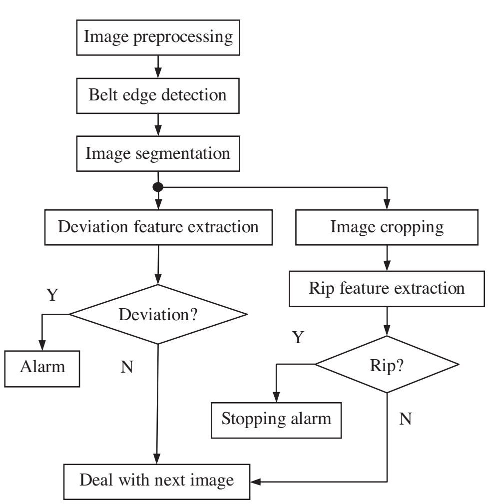

Fig. 2. Block diagram of belt faults detection.

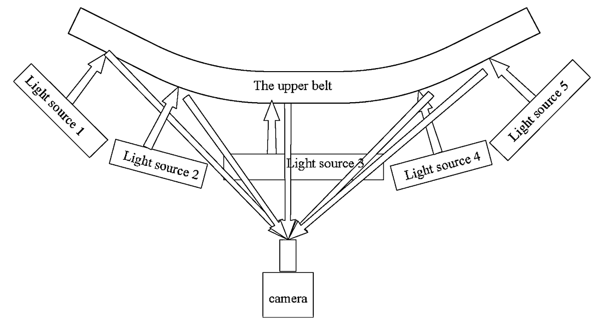

Fig. 3. Sketch map of the belt images acquisition.

2. Belt images acquisition

High-quality images help to enhance the accuracy of fault diagnosis, to reduce the image processing time and to improve the real-time of the visual inspection system. Compared with the plane-array CCD camera, the line-array CCD camera is more useful to detect one-dimensional moving target because it has a higher resolution. Taking into account the actual condition of the conveyor belt running, we use the line-array CCD camera with the high-brightness linear light source to capture high-quality belt images.

In the course of transportation, the upper belt which is the carrier tape is usually inclined upward, and the lower belt is approximately flat shape. Cameras are required to be mounted between the upper and lower belts to capture images from back of the upper belt. However, in engineering practice, the distance between the upper and lower belts is very small and it is less than the width of the conveyor belt. Even for the lower belt, the mounting place for the images capture device is also very small. Considering belt used in the coal industry, for example, the distance between the upper and lower belt is typically less than 1 m, but the belt width is usually greater than 1 m. In addition, the conveyor belt runs at a very high speed which is up to 6 m/s. Hence, it requires a unique design for the belts image acquisition system.

More than one camera can be mounted on a belt section to capture the belt images. However, it will inevitably lead to increased costs. Moreover, it needs to monitor belt on many sections for long-distance transport belts, which is not conducive to running an online monitoring system.

In this paper, more than one linear light source is adopted to provide light for the image capture device. The schematic of a single linear-array CCD camera equipped with five linear light sources to capture images of upper belts surface is shown in Fig. 3. On the plane of the conveyor belt with linear light sources, these five linear light sources are arranged in groove, which is in accord with the shape of upper belts. Line camera placed just below the belts. With a sufficiently large field of view of the lens and adjusting the linear light sources to an appropriate position, the CCD camera can image a whole section of the belt.

After belt images acquisition, image processing and fault diagnosis will be done to monitor the running state of conveyor belts. Therefore, the subsequent image processing speed and fault identification capability is crucial to inspect the running state of conveyor belts.

3. Belt image processing

The process of image processing includes image preprocessing, belt edge detection, and image segmentation. Usually, it has a lot of dust in the working environment of conveyor belts. It is necessary to preprocess the conveyor image for the sake of noise suppression. In order to improve the real-time of the system, a simple and

Download English Version:

https://daneshyari.com/en/article/848507

Download Persian Version:

https://daneshyari.com/article/848507

Daneshyari.com