Optik 168 (2018) 360–369

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Original research article

Laser-based on-line machine vision detection for longitudinal rip of conveyor belt

Xianguo Li[a,b,*], Lifang Shen[a], Zixu Ming[a], Can Zhang[a], Hangqi Jiang[a]

[a] School of Electronics and Information Engineering, Tianjin Polytechnic University, Tianjin 300387, China
[b] Tianjin Key Laboratory of Optoelectronic Detection Technology and System, Tianjin 300387, China

ARTICLE INFO

Article history:
Received 8 October 2016
Received in revised form 24 March 2018
Accepted 11 April 2018

Keywords:
Conveyor belt
Longitudinal rip
On-line detection
Line laser
Machine vision

ABSTRACT

Conveyor belts are widely used in mines, power plants, ports to transfer lump materials or products. They are prone to longitudinal rip in operation, which generally results in a stoppage of production, even causes belt break or longitudinal rip accidents for lacking the detection and treatment in time. It has long been recognized that a conveyor belt monitoring system for early detection of longitudinal rip is desirable. Based on the line laser detection technology, an on-line detection method is investigated to accomplish conveyor belt longitudinal rip detection rapidly and accurately, and the monitoring system utilizing machine vision technology is designed in this paper. A red line laser stripe projects on the surface of conveyor belt, and the image obtained by the corresponding CMOS camera is processed and analyzed to judge whether there is a rip on the belt surface or not. Firstly, the red stripe region of interest is segmented. Then, the skeleton representation of the stripe center and the binary image are obtained by maximum pixel value method. And the abnormal pixels, which correspond to the rip position, are detected by the neighborhood search method using the difference algorithm and the curvature method. Finally, the fault region is marked. Experimental results show that the proposed method is fast and high precise. This on-line detection method and system can effectively resolve the problem of conveyor belt longitudinal rip detection, and can be used during production hours with a full conveyor load.

1. Introduction

Conveyor belts are widely used in mines, power plants, ports and warehouses to transfer lump materials or products [1,2]. They are prone to longitudinal rip in operation, which generally results in a stoppage of production, even causes belt break or longitudinal rip accidents for lacking the detection and treatment in time. It has long been recognized that a monitoring system for early detection of longitudinal rip in conveyor belts is desirable [3].

At present, a variety of conveyor belt monitoring systems are developed, such as the mechanical system [4], electromagnetic sensor detection system [5–7], ultrasonic belt detection system [8–10], and radio frequency identification-based detection system [11,12]. Among them, the old and popular system is hanging a wire under the belt. If a foreign body penetrates the belt and moves that wire in the running direction of the belt, a stop of the motor is induced. Indeed, the penetrating

* Corresponding author at: School of Electronics and Information Engineering, Tianjin Polytechnic University, Tianjin 300387, China.
E-mail address: lixianguo@tjpu.edu.cn (L. Xianguo).
URL: http://13821156087@163.com (L. Xianguo).

https://doi.org/10.1016/j.ijleo.2018.04.053
0030-4026/

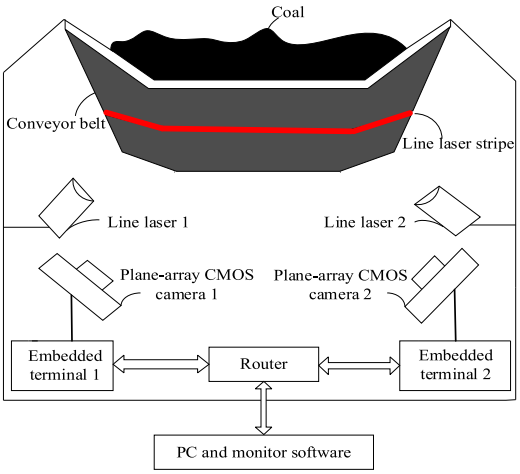

Fig. 1. Sketch map of laser-based longitudinal rip machine vision monitoring system.

body has to emerge long enough to contact and move the string. If the penetrating body is stuck somewhere and continuing to rip the belt, which is usually happening, the system cannot react[4,10]. The typical electromagnetic sensor belt rip detection system is induction loops/coils in combination with external transmitters and receivers. The loops are vulcanized into the belt or attached to the conveyor belt [6]. If a sensor loop is cut by a foreign body, no signal is transferred by the loop anymore - the receiver sensor does not get a signal and shuts off the conveyor drive. Sensor loops/coils are sensitive parts, which may trigger off false alarm. Also if high grade iron ore like magnetite, with very strong ferromagnetic properties, is being conveyed, the rip detection system may not work properly [5–7]. The ultrasonic belt detection system is generally used to transmit ultrasonic signals directly by conveyor belt, but the signal coupling is very difficult, and the vibration or impact of the conveyor belt will produce misjudgment [8–10]. Furthermore, this system does not work equally well to all types of belting, for this reason it require sample of the target belting for evaluation [8].The radio frequency identification-based rip detection system utilizes UHF RFID tags. And the UHF RFID tags incorporate the use of electromagnetic or electrostatic coupling in the radio frequency portion of the spectrum to communicate to and from the tag. So it also has the disadvantages of the electromagnetic sensor detection systems [11].

Because these systems listed above are imbedded into or attached to the conveyor belt, all of them have a limited fault detection capability. And none of the system has been used successfully in practice to detect longitudinal rip in conveyor belts. However monitoring conveyor belts by the machine vision technique can improve the detection efficiency and precision, so it has attracted much attention.

Ponsa et al. developed a computer vision detection system to detect defect of belts at a speed rate up to 2 m/s by using plane array camera to capture images [13]. Qi Junyan et al. [14] developed a machine vision detection system of conveyor belt longitudinal rip based on LabVIEW, using the multiple channel Planar Array CCD camera to capture the image, and using USB or 1394 interface for data transfer. Zhang Xi et al. [15] proposed a detection method on longitudinal rip based on USB plane array camera and ARM, and proposed image differential method for detecting the position of longitudinal rip whether there is the light transmission or not. Yang Yanli, Zhang Wei, Yang Yang, Li Jie, Qiao Tiezhu et al. separately proposed the machine vision method or algorithm for detecting longitudinal rip based on line array or planar array camera [3,16–19]. CBM, an international organization based in Australia, developed a longitudinal rip machine vision detection system [20].

For the above methods or systems based on the machine vision technique, the processed image is the whole collected image, and the image information of the conveyor belt is rich but the conveyor belt longitudinal rip characteristics information is unobvious, which directly affects the extraction of fault information and will finally lead to misjudge. So both the accuracy and speed of the longitudinal rip fault diagnosis of the conveyor belt can't be guaranteed.

In order to improve the real-time ability and accuracy, a new on-line machine vision detection method for conveyor belt longitudinal rip based on line laser is proposed, and the monitoring system is designed in this paper.

2. Laser-based machine vision monitoring for longitudinal rip

The sketch map of the laser-based on-line machine vision monitoring system for longitudinal rip as show in Fig. 1. The system mainly includes plane-array CMOS cameras, line laser sources, embedded terminals, PC and monitoring software and so on. The line laser sources and plane-array CMOS cameras are arranged between the upper and lower belts. The red laser stripe generated by line laser projects on the back of the upper conveyor belt, and it is vertical to the conveyor belt running direction. Because of the short imaging distance (about 35 cm), wide belt width (more than 100 cm) and vaulted shape of conveyor belt, several pairs of plane-array CMOS cameras and line laser soures along the width direction of conveyor belt can be placed side by side to cover the whole width of conveyor belt. For the 1.2 m wide(i.e. the width of the conveyor