Research on Enhancement Technology of Conveyor Belt Fault Images Based on Fruit Fly Optimization Algorithm

Chunqing Ye*, Changyun Miao, Xianguo Li and Yanli Yang

School of Electronics and Information Engineering, Tianjin Polytechnic University, Tianjin 300000, China

Abstract: In this research, we studied the fault recognition algorithm of steel cord conveyor belt, and obtained the wire ropes image by adopting the detection system of steel cord conveyor belt, so that the fault recognition algorithm of steel cord conveyor belt was proposed based on Fruit fly optimization algorithm. As we know that the fruit fly optimization algorithm is used for fault detection of the processing steel cord conveyor belt image and for obtaining the fault image. In the MATLAB environment, the algorithm process was designed and verified in terms of the effectiveness and accuracy. The experimental results show that with fast speed and high accuracy in detecting the fault image of steel cord conveyor belt rapidly and accurately, and in classifying scratch from fracture the proposed algorithm is suitable for the fault recognition of steel cord conveyor belt automatically.

Keywords: Fruit fly optimization algorithm, steel cord conveyor belt, wire rope image, fault detection algorithm.

1. INTRODUCTION

So far steel cord conveyor belt has been widely used in the industries such as mining, power station, steel mill, cement plant, ports. With the development of the coal industry represented by the comprehensive mechanization improvements and the increasing production capacity, steel cord conveyor belt has become the major transportation equipment. In the long-term use process, due to some reasons like increase of load, obstacles scratch, aging process, non-standard joint vulcanization, it will inevitably appear problems including the scratch of internal steel cord, rust-eaten and fracture of steel cord, tap offs caused by the decrease of adhesive force of steel cord and adhesive tape. If these problems are not detected and solved timely, breaking accident of steel cord conveyor belt will occur, causing material loss, equipment damage, huge economic losses and casualties and seriously shaking the safety production safety. Therefore, the detection system of steel cord conveyor belt needs to be developed so as to acquire wire ropes image of steel cord conveyor belt, and the fault recognition algorithm should be further studied in order to protect steel cord conveyor belt [1, 2].

2. DETECTION SYSTEM OF STEEL CORD CONVEYOR BELT

See the structure frame of detection system of steel cord conveyor belt in Fig. (**1**). The system is composed by X-ray generator, high speed X-ray detector, power supply, computers and system software and others.

In the detection system, doubtlessly, the X-ray generator can produce X-ray. Consisting of the photoelectric conversion module, signal acquisition module, the signal processing transmission module and power module, the high speed X-ray detector is responsible for collection, processing and transmission of the high-speed signal. While the computers and system software will take charge of the display, storage, processing and fault recognition of the wire ropes image.

The working process of the steel cord conveyor belt detection system:

1. X-ray produced by X-ray generator penetrates the running steel cord conveyor belt into the photoelectric conversion module of high speed X-ray detector;

2. Optical signal of the image is firstly transformed into electric signal by the photoelectric conversion module, and then through the signal acquisition module of X-ray detector, the electric signal undergoes amplification, filtering and A/D conversion process before converted into digital signal, and finally the digital signal is sent to the signal processing transmission module.

3. Undergoing the noise reduction process, calibration and homogenization treatment in the signal processing transmission module, the digital signal is transferred to the PC for further imaging process of wire rope and recognition of steel cord conveyor belt, with the presence of fault alarm signal being sent out.

3. WIRE ROPES IMAGE FEATURES OF STEEL CORD CONVEYOR BELT

The wire ropes images obtained through steel cord conveyor belt detection system can be divided into normal image and fault image wherein, the fault image includes conveyor belt fracture image and conveyor belt scratch image.

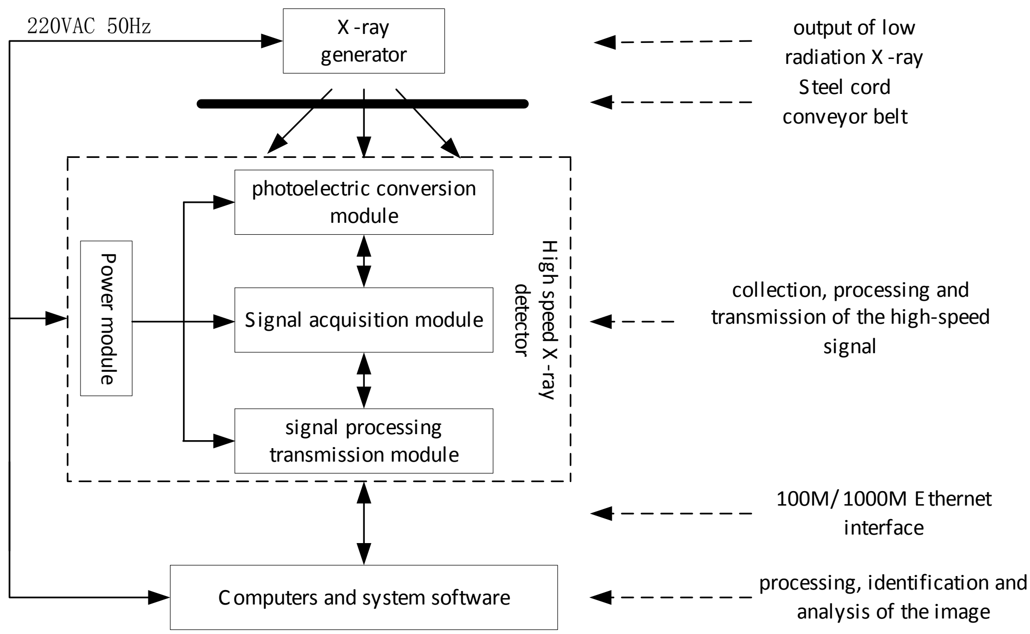
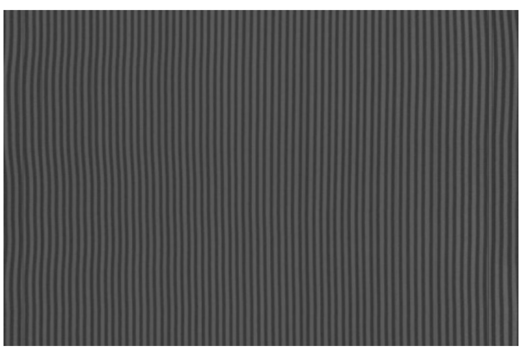
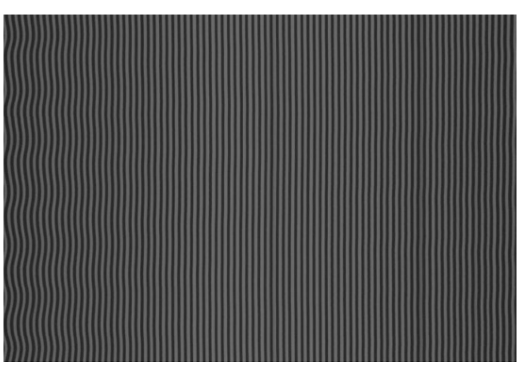


Fig. (1). The structure frame of steel cord conveyor belt detection system.

See Figs. (**2**) and (**3**) below, we can see that different widths of steel cord conveyor belts match different pixel points of detectors based on X-ray, so the widths of pictures are various. The X-ray image width of the 1.2 meter wide belt conveyor is 832 pixels, and that of 1.4 meter is 960 pixels.



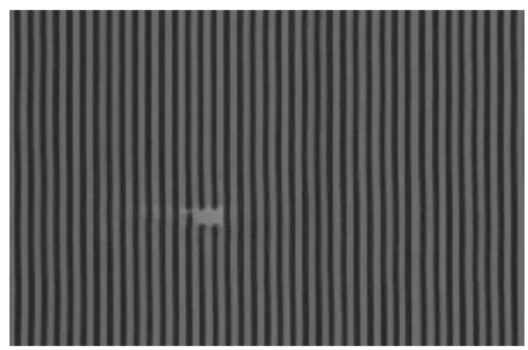
(a) Conveyor belt with wire ropes #image 1



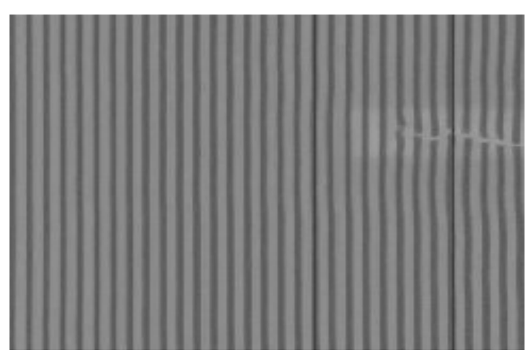
(b) Conveyor Belt with Wire Ropes # image 2

Fig. (2). The normal picture of conveyor belt with wire ropes.

From Fig. (**3**), we can see that X-ray image of steel cord conveyor belt has stronger texture, in almost all zones of the X-ray image, there appears regular stripe texture except for the fault zone, and the grey scale of image changes regularly because of the longitudinal arrangement of wire ropes in a certain distance. Therefore the X-ray image of the steel cord conveyor belt is texture image, which has strong cyclical



(a) Conveyor belt fracture image



(b) Conveyor Belt Scratch Image

Fig. (3). Fault image of conveyor belt image with wire ropes.

characteristics. The conveyor belt fracture and scratch areas exhibit irregular change of the. Therefore, the study of cyclical extraction technique is of certain theoretical guiding significance, which solves the problems in automatically detecting the steel cord conveyor belt faults. In this paper an algorithm based on fruit fly optimization algorithm was adopted for fault detection of the wire ropes.

4. FRUIT FLY OPTIMIZATION ALGORITHM

Fruit fly optimization algorithm FOA) is a new evolutionary computing method proposed by Pan Chao, a young teacher in Taiwan [1] in 2011. Global optimization by simulating the foraging behavior of fruit flies seeks fresh processes which are shown in Fig. (**4**).

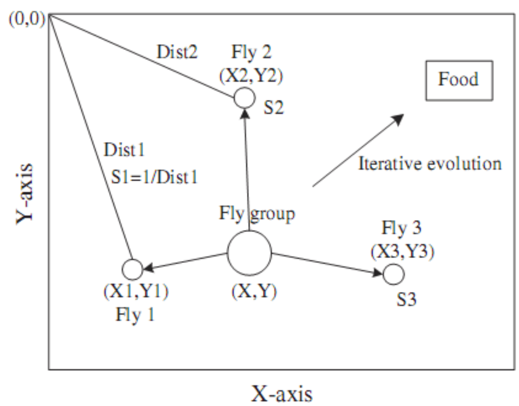


Fig. (4). Iterative Food Search Behavior of Fruit Fly Group. The general model of design of landscape sculpture.

Algorithm Steps: Fruit fly optimization algorithm can be divided into seven steps as follows:

(1) The initialization position of fruit fly groups, the result is initialized $Init\ X\_axis$; $Init\ Y\_axis$.

(2) After the search directions RV_x and RV_y are settled, the random search distance of individual fruit fly can be obtained by the following formula:

$$X_i = Init\ X\_axis + RV \quad (1)$$

$$Y_i = Init\ Y\_axis + RV_y \quad (2)$$

(3) Due to the unknown food position, individual fruit fly needs to estimate the distance between the current location and the origin. Flavor concentration (equals the reciprocal of the distance) is calculated after determining the value of S_i

$$Disti = \sqrt{X_i^2 + Y_i^2} \quad (3)$$

$$S_i = 1 / Disti \quad (4)$$

(4) The determinated values of flavor concentration are put into the concentration determination function so as to obtain the flavor concentration of the current position of the individual fruit fly.

Smelli = Function (Si) (5)

(5) The optimum flavor concentration of fruit fly groupscan be obtained by the following formula:

$$\left[bestSmell\ bestIndex\right] = \max(Smelli) \quad (6)$$

(6) Retain the best flavor concentration and the population corresponding x and y coordinates of fruit fly groups. Then through its own visual positioning of the food source, toward the position of the food.

$$Smellbest = bestSmell \quad (7)$$

$$X\_axis = X(bestIndex) \quad (8)$$

$$Y\_axis = Y(bestIndex) \quad (9)$$

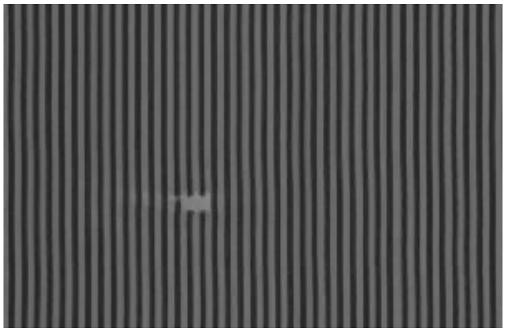
(7) Iterative optimization: throught iterative steps (2) - (5), we can determine whether the favor concentration better than the previous iteration flavor concentration. If it is satisfied, then go back to step (6). Fruit fly optimization algorithm experiment and result analysis

The experiment firstly detected the common scratchs and fractures of the steel cord conveyor belt as well as other faults of conveyor belt. The detection database is composed by 2996 X-ray images of four steel cord conveyor belts in four different coal mines. The detection database of four types of faults of each conveyor belt is shown in Table **1**.

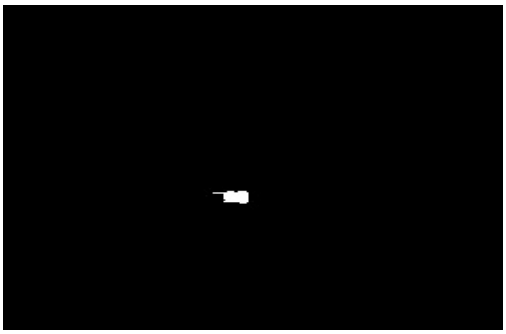
The size of conveyor belt in number 1 and number 3 is 600×832 pixel, while the size of conveyor belt in number 2 and number 4 is 600×960 pixel. The first picture without

Table 1. Fault detection database of steel cord conveyor belt.

Number	Conveyor Belt Fracture	Conveyor Belt Scratch	Other Faults of Conveyor Belt	Total Images
I	0	2	9	740
II	10	13	0	1087
III	2	0	1	430
IV	0	0	15	739
Total	12	15	25	2996

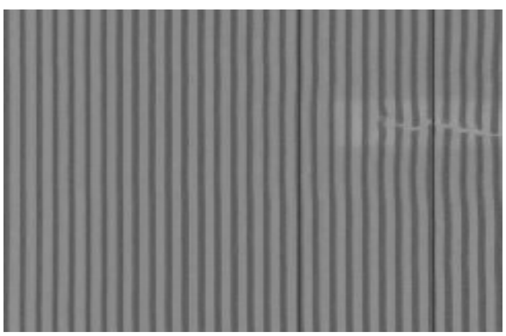


(a) Conveyor belt fracture image

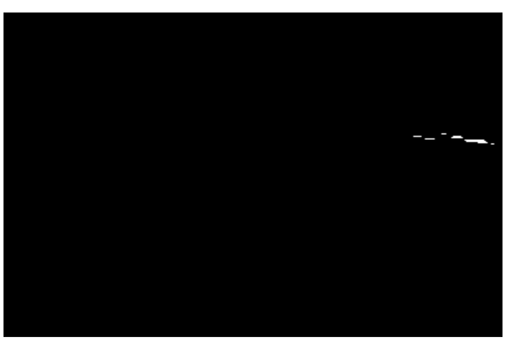


(b) Conveyor Belt Fracture Image using Fruit Fly Optimization Algorithm

Fig. (5). Conveyor Belt Fracture Image using Fruit Fly Optimization Algorithm.



(a) Conveyor Belt Scratch Image



(b) Conveyor Belt Scratch Image using Fruit Fly Optimization Algorithm

Fig. (6). Conveyor Belt Scratch Image using Fruit Fly Optimization Algorithm.

fault information is selected as the training image. The faults in the four conveyor belts images were successfully detected with 100% rate of accuracy. When the n value is 12, α is default value 1 and statistical threshold of the white pixel is 5. The detection results of fault zones in different images are shown in Figs. (**5**) and (**6**), wherein the Fig. (**5**) shows conveyor belt fracture image using fruit fly optimization algorithm, The Fig. (**6**) shows conveyor belt scratch image using fruit fly optimization algorithm Figs. (**5**) and (**6**) show that the faults can be well detected through fruit fly optimization algorithm in high detection accuracy, leaving a well display of fault shape, and laying foundation for further fault analysis fault.

5. CONCLUSION

In this research, we studied the fault recognition algorithm of steel cord conveyor belt, and obtained the wire ropes image by adopting the detection system of steel cord conveyor belt, so that the fault recognition algorithm of steel cord conveyor belt was proposed based on fruit fly optimization algorithm. The training stage and detection stage of the proposed detection algorithm have been studied, and programming and analysis of the results achieved by fruit fly optimization algorithm have been carried out. The results show that the conveyor belts fault image can be significantly optimized detected rapidly and accurately. With high accuracy of detection and classification, the algorithm possesses a high application value in the production of steel cord conveyor belt.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

ACKNOWLEDGEMENTS

National Natural Science Foundation of China (No. 51274150);

Key Project of Tianjin Municipal Science and Technology Support Program (No. 13ZCZDGX01000);

Key Project of Tianjin Application Foundation and Frontier Technology Research (No. 12JCZDJC27800);

Support Project of Science and Technology Development Fund in Tianjin High School (No. 20130708).

REFERENCES

[1] J. Mao, Y. S. Zhao, and S. J. Wang, “Reason and Prevention of Portrait-tear with Belt Conveyer”, *Coal Mine Machinery*, vol. 28, pp. 182-183, 2007.

[2] H. Y. Shen and W. B. Qin, “Application Study of Wire Ropes Conveyer Belt on Line Safety Examination System”, *Coal Mine Machinery*, vol. 27, pp. 679-681, 2006.

[3] T. R. Liu, and W. B. Qin, “Study of the Wire Rope Conveyer Belt Safety Examination System”, *Inner Mongolia Petrochemical Industry*, vol. 32, pp. 13-15, 2006.

[4] S. Gao and Y. L. Gao, “How to Set Display Mode in Full Transect Detector for the Conveyer Belt with Steel Wire Ropes in Real Time”, *Computer Simulation*, vol. 21, pp. 181-183, 2004.

[5] L. Ma, W. F. Wang, and S. F. Zou, “Liver Focus Detections based on Visual Attention Model, Third International Conference on Bioinformatics and Biomedical Engineering”, 2009, pp. 1-5.

[6] B. Cirak, “Analysis of Empirical Viscosity Models of Polymer Flow in PVC Extrusion Process”, *Advances in Industrial Engineering and Management*, vol. 3, no. 4, pp. 19-26, 2014.

[7] H. Y. T. Ngan and G. K. H. Pang, "Regularity Analysis for Patterned Texture Inspection", *IEEE Trans. on Automation Science and Engineering*, vol. 6, pp. 131-144, 2009.

[8] B. S. Collobertr, "SVM torch: A Support. Vector Machine for Large Scall Regression and Classification Problems", *Journal of Machine Learning Research*, vol. 1, pp. 143-160, 2001.

Received: July 23, 2014 Revised: September 12, 2014 Accepted: October 02, 2014