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RESEARCH ON REAL-TIME DETECTION OF LARGE-GRANULARITY GREEN PELLETS BASED ON YOLOV3 ALGORITHM

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In order to realize the real-time detection of abnormal green pellet particle size. First, image data of large-granularity green balls at different disk pelletizing machine material disk speeds and different camera angles are collected on site; then LabelImg software is used to label the image data of large-granularity green balls; and finally based on the YOLOv3 algorithm under the Pytorch deep learning framework train and detect large-grained ball image data. The experimental results show that: under the condition of high rotation speed of the material disk of the disc pelletizing machine, the detection accuracy can reach more than 90,58 % for the image data of a single large-grained green ball, and the comprehensive detection rate can reach more than 85 %.

Keywords: green pellets, detection, granularity, deep learning, YOLOv3

INTRODUCTION

Pellets are made by adding a small number of additives to finely ground iron concentrate powder or other iron-containing powders, then rolling them through a disc pelletizing machine into green pellets under the condition of adding water and moistening them, and then drying and roasting them to solidify them into green pellets. A spherical iron-containing raw material with certain strength and metallurgical properties. Green pellets are an important intermediate product in the pellet production process. The particle size of green pellets is an important indicator. The particle size of green pellets refers to the diameter of the green pellets. Generally, controlled at 10-30 mm, those with a diameter greater than 30 mm are considered large-grained green balls, which are abnormally sized green balls, as shown in Figure 1. At present, the particle size detection of green pellets mainly relies on manual visual inspection. This method not only has low detection efficiency and poor accuracy, but also the particle size information cannot be fed back online in real time, which seriously affects the quality of pellets[1]. The classic deep learning yolov3 algorithm is used to solve the problem of online real-time detection of large-grained pellets. It can detect large -grained green balls in time and notify the ball removal process. The detection results can also be fed back to the pellet mixing system in a timely manner. By adjusting the processing Process parameters such as water volume control the size of the pellets, forming a closed-loop system for pellet mixing production. Replacing manual on-site detection will greatly improve the automation and production efficiency of production[2,3].

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The disc pelletizing machine is an important equipment for making green balls in the pellet production process. When the disc rotates around the central axis, the balling materials roll along the bottom of the disc, and the fine-grained materials are continuously adsorbed on the surface of the moist cue ball, thus making the cue ball Continuously grow to the required size. Its working characteristics: the material moves regularly, larger pellets and smaller pellets run along their own different orbits, and green pellets of qualified size are discharged according to size classification.

Figure 1 Large -granularity green pellets

In recent years, domestic and foreign research on adhesion image segmentation and granular Research on degree detection continues to make progress, and applications are becoming more extensive. Zhang et al[4] successfully used morphological edge detection. The particle size distribution of coal can be estimated accurately. Dai Dan[5] adopted a modified. Adaptive watershed algorithm was introduced to successfully remove the adhesion areas in the image. The domain is segmented and compared with the direct watershed algorithm. The improved adaptive watershed algorithm

has better segmentation effect. Considering that some researchers have successfully applied yolo to real-time detection of surface defects on steel strip surface[6,7].

Judging from the existing literature, there are many detection methods for large - granularity green pellets, and there are few studies based on artificial intelligence deep neural networks. Therefore, this article uses the classic YOLOv3 algorithm to build a large-granularity green pellet detection algorithm model. The image data of the production site of the disc pelletizing machine was collected from different angles, and the image data of the raw pellets with abnormal particle size in the disc pelletizing machine were marked through LabelImg software. Under the Pytorch deep learning framework, the production site was trained based on this algorithm. Based on the image data, the trained weights are used to detect the abnormal granularity of raw balls in the image data in real time to promote the intelligentization process of steel enterprises.

SYSTEM COMPOSITION AND PROCESS

The hardware part of the pellet particle size detection system consists of a CCD camera, computer, light source, and camera holder. The camera uses an ordinary industrial CCD camera with an image collection frequency of 30-100FPS and a ring light as the light source. Python language is used to develop the detection system application in the pycharm environment. The function consists of three parts: image acquisition, image processing algorithm and result display. The image acquisition function is implemented through secondary development of the camera SDK development package. The system process can be divided into automatic timing acquisition and detection and manual acquisition and detection. The specific workflow is as follows: First, after the CCD camera and light source and other hardware equipment are installed, the camera needs to be calibrated and parameter adjusted. After the camera height is determined, the camera parameters are adjusted. until the image is clear. If you choose continuous detection, set the time interval for regularly collecting images, the storage path of the collected images, the path for saving the granularity statistical detection results and other parameters. After the parameters are set, the system will be in the automatic detection state and complete image acquisition, preprocessing, object segmentation, and granularity detection in sequence. With statistics, the detection results are displayed on the interface and saved in .txt file format. When the system needs to be stopped in the continuous detection mode, it needs to be stopped manually.

PRODUCTION OF DATA SET OF ABNORMAL SIZE GREEN PELLETS

Since deep neural network training requires a large amount of on-site raw pellet data images, the commonly used pelletizing equipment is the φ 6 000 disc pelletizing machine. The small-sized models are divided into φ 3 500, φ 4 500, φ 5 500, etc., and the large-sized models are divided into φ 7 000, φ 7 500, etc. Production lines with different outputs can be adjusted by increasing or decreasing the number of disc pelletizing machines. This article takes theφ6000 disc pelletizing machine as an example to collect a raw ball image data set. Considering the site conditions, the inclination angle of the disc pelletizing machine is about 6°, and the raw balls will naturally fall with gravity. Choose a location that is convenient for observation to install the camera, which is located directly above the bottom of the material tray. This paper reasonably collects different image data from three aspects: different material disk rotation speeds, different camera shooting angles, and different numbers of large-grained green balls, and creates an image data set. A total of 1200 data set pictures were produced. The specific rotation speed of the material disk is 0,35~1,35 m/s, and the rotation speed range are generally 8~16 r/min. The rotation speed of the material disk is used as an experimental parameter. The purpose is to take advantage of the characteristic of image blur caused by moving images, and deliberately adopt conventional acquisition frequencies. For a low-profile CCD camera, when the pellets run along their own different trajectories, a speed difference will occur. Large-sized pellets move slowly, making it easy to distinguish the detection target image from the background image. The camera shooting angles are middle, left and right respectively; the camera overhead angle ranges from 0°to 90°. The data set is obtained by shooting from three angles: left angle, middle angle, and right angle, taking pictures of the disc pelletizing machine from different angles and angles. The number of large-grained green balls in the field of view of the disc pelletizing machine ranges from 1 to 8.

DETECTION EXPERIMENT BASED ON YOLOV3 ALGORITHM

After making a data set and naming the images in the data set according to certain rules, label each large-grained ball image through labelImg, and then use the labeled data set to train the YOLOv3 network. The training environment of this article is as follows: Ubuntu20 system, graphics card GTX3070 (16 GB video memory), python3, 6,2 (64-bit), and the dependent libraries installed in the pycharm environment are: pandas,numpy, pillow,matplotlib, opencv-python, scikit-image, torch1. 2,0, torchvision0,4,0, cuda10,2 and zisan. This experiment uses the YOLOv3-tiny network model. YOLOv3-tiny is a simplified version of YOLOv3. The YOLOv3-tiny network structure model is shown in Figure 2 The input image size is 416×416-pixel density (Pixels Per Inch, PPI), the number of iterations is set to 1 000, the batch size is 8, the momentum parameter is 0,9, the attenuation coefficient

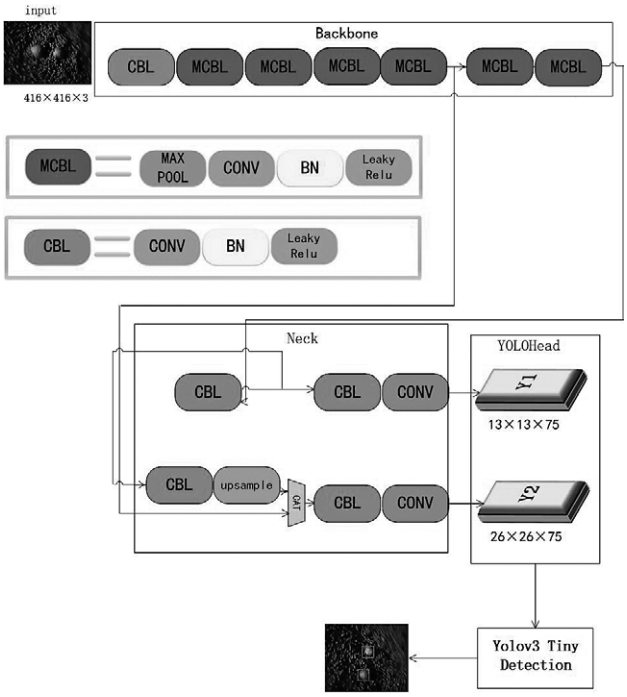


Figure 2 Structure diagram of YOLOv3-tiny

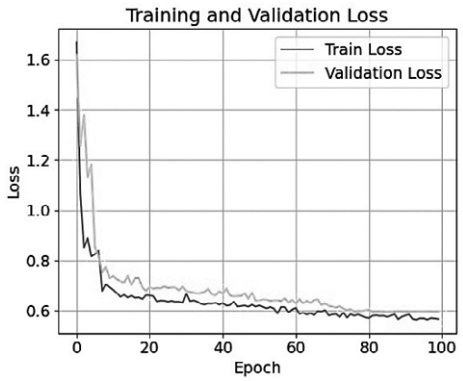


Figure 3 Structure diagram of YOLOv3-tiny

is 0,0005, and the initial learning rate is 0,001, Category1. After YOLOv3-tiny network model training, the Mean Average Precision (MAP) is a measurement value for evaluating target detection, and the loss value is less than 0,1. Figure3 shows the performance indicator curve generated by the experiment.

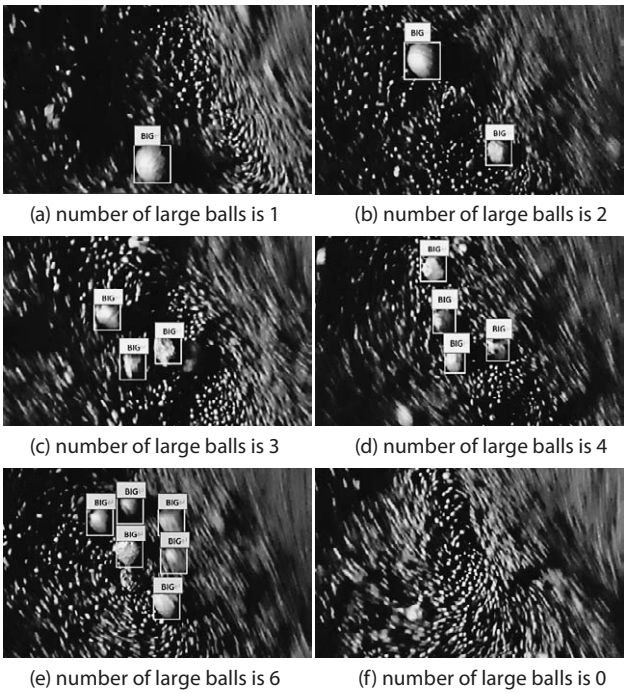
LARGE SIZE GREEN BALL DETECTION RESULT AND ANALYSIS

Large particle size green ball test results display

Abnormally sized green pellets after YOLOv3 training. Figure 4(a) shows the detection results from the middle perspective when the number of large-granularity pellets is 1. Figure 4(b) shows the detection results from the left perspective. the test result picture of the number of large-granularity green balls is 2, Figure 4(c) is the test result picture of the right-side view, the number of large-granularity green balls is 3, Figure 4(d) is the middle view angle, the number of large-granularity green balls is 4. Figure 4(e) shows the detection results of the number of large-granularity green balls of 6 when the material disk of the disc pelletizing machine rotates at a high speed from the middle perspective. Figure 4(f) is a picture of the detection results of 0 large-granularity green balls from the left perspective, when the disc pelletizing machine's material disc rotates at low speed. It can be seen from Figure 4 that under the conditions of different disc pelletizing machine material disc rotation speeds, different numbers of large-granularity raw balls, and shooting from different angles, the trained YOLOv3 model can effectively detect large -scale raw balls. Granular green balls.

Analysis of accuracy of large particle size green ball detection

In the experiment, the effects of different disc pelletizing machine material disc rotation speeds, different camera angles, and different numbers of large-granularity green balls on the detection accuracy were designed. The results show that the higher the rotation speed of the material tray, the higher the detection rate of large-granularity green balls. On the contrary, the lower the rotation speed of the material tray, the lower the detec-



(a) number of large balls is 1 (b) number of large balls is 2

(c) number of large balls is 3 (d) number of large balls is 4

(e) number of large balls is 6 (f) number of large balls is 0

Figure 4 Detection results of large -granularity green pellets

Table 1 **Detection accuracy of different status**

Level Rank	High Speed/%	Normal Speed/%	Low Speed/%
1	90,58	88,65	80,33
2	89,45	86,58	80,24
3	89,54	85,96	80,78
4	88,66	85,47	79,88
5	88,98	84,67	78,82
6	85,35	80,66	75,51
7	75,69	70,41	65,77

tion rate of large-granularity green balls. When the number of large-granularity green balls is greater than 6, the detection rate of large-granularity green balls will be lower. The accuracy rate has declined; the camera angle has little impact on the detection accuracy rate. Table 1 shows the detection accuracy at different material tray speeds from different viewing angles. The first column represents the number of large-granularity green pellets, and the next three columns represent the detection accuracy at high, medium, and low material tray speeds. Accuracy. It can be found from the table that the lower the rotational speed, the lower the detection rate. The main reason is the background blur caused by the moving image. The large-grained raw ball is in the center of rotation, but is relatively static, the image is clear, and the contrast with the background is large. Therefore, learning and recognition effect is good. When the number of large-granularity green pellets is greater than 6, the recognition accuracy is low. Multiple large-granularity green pellets will be closely together due to gravity, which is not conducive to learning and identification. It has little impact on the detection results when viewed from the left, middle and right angles of the camera position. Therefore, the camera should be installed in a place with a relatively open field of view, and there are no special requirements for the installation angle.

CONCLUSIONS

The image experimental data collected on site verified that the YOLOv3 neural network can be used to effectively detect large-grained green balls. The camera setting orientation has little effect on the detection effect of large-grained green balls. As the rotation speed of the material disk of the disk pelletizing machine increases, the detection rate of large-granularity green balls increases. When the speed decreases, the detection rate decreases. When the number of large-grained green balls is higher than 6, the accuracy of detecting large-grained green balls decreases.

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Note: The responsible translator for English language is Zen Yang, Anshan, China.