

Intelligent poultry seedling sorting system based on convolutional neural network

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Abstract: In view of the outstanding labor costs and high health and safety risks in the traditional poultry seedling sorting process, an automatic equipment suitable for the sorting of poultry seedlings was designed through the research on the extraction of the characteristics of a variety of poultry species. According to the different types of poultry seedlings, there are many different sorting requirements for chicken seedlings, duck seedlings, goose seedlings, etc., thus providing a classification and recognition method that combines visual information technology and convolutional neural network (CNN) technology to form a hardware and software collaboration framework to meet the functional requirements for image acquisition, processing and real-time detection of different poultry seedlings. First of all, we use camera technology to extract the features on the shape of the bird seedlings into the system and wait for the next step of correlation analysis; Then, based on CNN technology, different species of the same bird vaccine are classified; Finally, sorting is realized through hardware collaborative processing. For each kind of poultry seedlings, multiple trainings shall be conducted, and the corresponding database shall be established to improve the sorting accuracy. The results showed that the recognition accuracy of different types of poultry seedlings was 100%, the recognition accuracy of different types of poultry seedlings of the same species was 97.7%, and the recognition speed was 0.049 seconds, which could meet the requirements of efficient sorting of 8000 poultry seedlings per hour.

Keywords: Convolution neural network; Sorting equipment; Visual technology

1. Introduction

With the development of society and the improvement of people's living standards, poultry meat has become an indispensable food in daily life, especially the demand for chicken. According to the current survey on the social market, chicken has become the second most needed meat in the world. It is relatively the main ingredient or diet in a series of fields such as pet raising, bodybuilding and health preservation. From the perspective of the chicken industry situation in 2021, China's chicken industry has been growing. As shown in Fig 1.

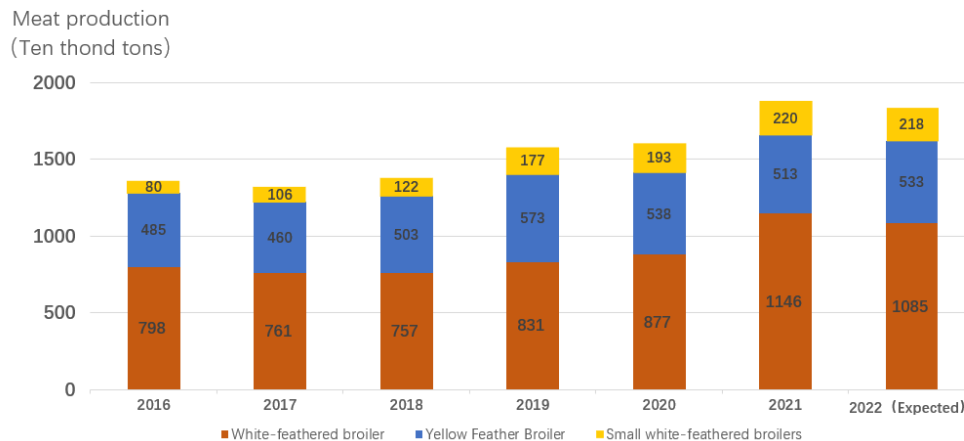


Figure 1: Change Trend of Chicken Production from 2016 to 2022

The number of chicken sold was about 11.83 billion, up 7.4% year on year; The chicken output is 19.891 million tons. Year on year growth of 7.9% [[1] China's animal husbandry. Development situation of broiler industry in 2021 and prospects for 2022. Issue 3 in 2022.]^[1]. The change trend chart in Figure 1 shows the change trend of the total chicken production from 2016 to 2022 (of which 2022 is the expected data). It can be predicted that China's chicken production will continue to grow in the next few years. Therefore, it is relatively important to ensure the stable supply and demand of poultry meat.

For most poultry, the male and female sorting of chicks is the first step of breeding. Take chicken fry as an example. As far as the last century is concerned, the breeding requirements for chickens have always been for both eggs and meat. For the current market, in order to save breeding costs and improve sales revenue, poultry farms basically have the demand for specialized poultry fry - eggs or meat. In most cases, the commercial value of commercial male chicks for laying hens is low, so male chicks have become an important component of pet feed, similar to cat food and dog food. In addition, the cost of raising male chicks is relatively high, and the meat quality cannot be guaranteed, which is not conducive to the sale of breeding eggs and newborn chicks at an appropriate price in the market [[2] China Poultry Vol.30, No.20.2008.]^[2].

As far as the current poultry seedling processing plants or integrated incubators are concerned, the most important sorting method of poultry seedlings has always been manual sorting, in which the anal hair and feather speed methods are the most commonly used. Affected by market demand, sorting error rate, sorting efficiency, sorting cost and other factors, manual sorting has gradually ceased to meet the demand for poultry meat in the current society.

Image classification is one of the basic tasks of computer vision. As the name implies, image classification refers to a given image, and the computer uses algorithms to find its category label^[3]. In recent years, with the development of deep learning, especially the Convolutional Neural Network (CNN), it is rapidly becoming the preferred method to overcome the above challenges^[4]. With the constant introduction of new technologies, the emergence of new methods such as linear correction unit [10] (corrected linear unit, ReLU), parameter modified linear unit (PReLU [11]), DropConnect [12] and Drop [13] effectively avoids the over fitting problem in model training and enhances the ability of convolutional neural network. Image classification through convolutional neural network is an application of deep learning on image processing. This processing method of directly convolving with image pixels and extracting image features from image pixels is closer to the processing method of human brain visual system, which is a major advantage of convolutional neural network. It is an image recognition method based on convolutional neural network. Depending on its characteristics of multi-level and multi structure, the captured features are gradually amplified into more abstract and clear features. Because of this extremely strong feature analysis ability and learning ability, the recognition and resolution ability of convolutional neural network is more accurate. Compared with direct training on target data set, the method of using convolutional neural network to conduct model pre training on ImageNet^[5] data set and then dividing it into other small data sets for training can greatly improve the resolution of images^[6]; If the convolutional neural network is directly used as a fixed feature extractor, and the full connection layer of the network structure is replaced by the SVM classifier as the output of the final classification and recognition results, this method strictly limits the specification of the input image, and is not strong for any scale image expansion^[7].

On the basis of the existing methods, this paper proposes a method of bird seedling feature image recognition which combines convolutional neural network and vision technology. This method uses visual technology to obtain the trained model features, and uses convolutional neural network to amplify and distinguish the obtained features at multiple levels. Fine tune the image in the training process, and finally classify it with the optimal training model. According to the result of the dataset formed by multiple training, the method used in this paper has higher accuracy and timeliness in poultry seedling sorting^[8-9].

2. Intelligent poultry seedling sorting method based on convolutional neural network

The intelligent bird seedling recognition method based on convolutional neural network proposed in this paper mainly includes the following steps: ① using visual technology to extract the bird seedling image. ② The extracted image information is further abstracted through convolutional neural network to expand the characteristic attributes and the number of samples contained in the dataset; ③ Collate and merge the extracted features, and establish the corresponding database to train the convolution neural network; ④ MCU chip accepts the resolution results of convolutional neural network and

outputs them to achieve final sorting.

2.1 Classification algorithm of male and female poultry seedlings based on feature extraction of poultry seedlings

In this paper, we use visual technology to extract feature images. Based on image processing technology, we propose two classification methods for different growth characteristics of male and female chicks. The first method is to realize male and female sorting of brown egg chicks by distinguishing the extracted image color blocks. However, this method is difficult to accurately sort white feather chickens with relatively small appearance color features, ducks, geese and other chicks without obvious color features. By using convolutional neural network to extract a series of certain appearance features such as feathers and nostrils of poultry seedlings, and using convolutional neural network to abstract, magnify and identify, we can better distinguish different sexes of poultry seedlings. However, in order to ensure a high accuracy, it is necessary to establish a very wide range of data sets. In this paper, through the training of male and female sorting of a variety of bird seedlings, a database for different physiological differences of different bird seedlings is established, which greatly simplifies the operation complexity and algorithm fluency while ensuring the sorting efficiency of bird seedlings.

2.2 Software and Hardware Collaboration

In order to simulate the working mode of the future production line, the image acquisition, sorting and processing of poultry seedlings and other functions, software and hardware need to work together. In this paper, the hardware and software cooperation architecture in Fig 2 is adopted. At the beginning, the image data of the poultry seedlings is extracted through the image sensor, the relevant parameters of the recognition algorithm are read through LPDDR4, and the computer uses convolutional neural network to process the extracted image data. After that, the sorting information is transferred to the hardware, and the instructions are transmitted to the sorting mechanical equipment through the microcontroller to sort the male and female poultry seedlings, and then

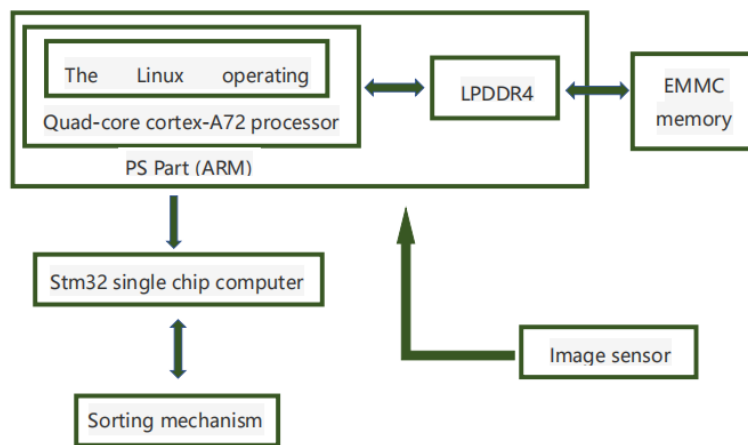


Figure 2: Hardware and software collaboration framework

3. Building experimental model and data set processing

As far as the current poultry seedling market is concerned, it is the simplest and most efficient method to apply the image processing technology to the production line for male and female sorting of poultry seedlings. Therefore, it is also the preferred method for domestic and foreign poultry sorting companies. A series of western countries, such as the Netherlands, Canada and Australia, have tried to use picture technology to produce a series of poultry products, such as large eggs and poultry meat.

However, compared with small chicks, the parts that can be distinguished are very small and relatively secret, such as the feather speed of chicken chicks, nostrils of duck chicks, etc. There are some limitations and inaccuracies in simply using manual sorting or weighing sorting. Aiming at the current sorting mode, this paper adopts the system mode of visual technology combined with convolutional neural network to build a software and hardware combination model that can simulate the poultry

seedling sorting, and provides an intelligent poultry seedling sorting system based on convolutional neural network, which is used to solve the problems of low efficiency in the current background of too long sorting and easy to lead to chicken seedling disability and death.

3.1 Hardware composition of intelligent poultry seedling sorting system

The hardware module of the intelligent poultry seedling sorting system is mainly composed of two parts: the conveyor belt used to transmit poultry seedlings and the sorting control rack. The sorting control rack includes a column to be sorted for receiving poultry seedlings, two boxes for placing male and female poultry seedlings, high-definition camera, and front and back rotation motors. The column to be sorted for poultry seedlings is placed directly below the terminal point of the transmission belt for poultry seedlings, and the two boxes for placing male and female poultry seedlings are respectively located at the oblique lower part of the column to be sorted for poultry seedlings and at a balanced position. A transmission track is installed between the two boxes. In front of the rack, a camera is installed directly above the transmission belt to collect image feature data. The camera and the microcomputer are connected through signal transmission, and one end of the sorting column is connected with the positive and negative rotation motors through the transmission shaft. In addition, a hardware receiver is installed above the front and back tilter, which is connected with the a microcomputer through a signal transmission line.

3.2 Operation mode of intelligent poultry seedling sorting system

The specific operation mode of the intelligent bird seedling sorting system is as follows: the bird seedlings to be sorted are transported to the sorting machine through the conveyor belt. When the bird seedlings arrive at the end of the conveyor belt, the bird seedlings fall into the column to be sorted directly below the conveyor belt; When a bird seedling falls into the column to be sorted, the photo camera at the top starts to shoot the bird seedling, and transmits the collected picture to the microcomputer through the signal transmission channel, and recognizes and classifies the received picture through the convolutional neural network; The identified results will be sent to the hardware layer through the signal transmission line. The hardware layer will make corresponding operations after receiving the results, and update the results to control the positive and negative overturning motor; According to the result, the reversing motor turns left and right to send the bird seedlings into the corresponding male and female placement column along the track, so as to quickly realize the intelligent sorting of male and female bird seedlings by the system.

3.3 Acquisition of training data set of intelligent poultry seedling sorting system

In order to establish a database for testing the male and female sorting of chick seedlings, 9000 chick seedlings of 5 species of brown shell egg line were selected, including 4500 female chick seedlings and 4500 male chick seedlings. 5000 white feather chickens were selected, including 2500 female white feather chickens and 2500 male white feather chickens. Each time, the bird seedlings are placed in the center to be sorted, and the light intensity is adjusted to ensure the clarity of the acquired image. In addition, in order to obtain more characteristic data of bird seedlings and the individual activity of bird seedlings in the sorting process, each angle of the bird seedlings is shot reversely, with emphasis on the feather part.

4. Image recognition algorithm flow

The first step is to adjust the transmission speed of the conveyor belt and the exposure value of the camera respectively according to the impact of the conveyor belt on the picture definition and the surrounding light intensity under different transmission speeds, so that the system can collect the clearest picture information under the fastest movement. In the second part, according to the data characteristics of the differences between male and female chicks, the recognition and classification method based on convolutional neural network is adopted to improve the accuracy of the system for the recognition of male and female chicks.

4.1 Acquisition of bird seedling image

Influenced by the objective factors of conveyor belt speed and the activity of poultry seedlings,

reasonable camera parameters are very important. Once the parameter setting is wrong, the image quality obtained by the system will be damaged, and the subsequent system's image recognition processing and analysis will also be damaged accordingly. The exposure value is too low, which is easy to cause the acquired image to be relatively dark; If the exposure value is too high, it is easy to cause motion blur of the image acquired by the system. For this reason, after many tests, the system found that the running speed of the conveyor belt was adjusted to 7.3m/min. By setting the white balance to automatic and the absolute exposure value to 43, the pictures obtained were clearer and less affected by motion blur.

4.2 Image data preprocessing and classification method based on convolutional neural network

In order to ensure the high quality of the image data obtained, increase the feature diversity of the image data obtained, test the processing effect of the convolutional neural network model on more information in a complex environment, and the model performs preprocessing on the image data of the bird seedlings obtained, including data annotation, data enhancement, etc. Only through supervised training and labeling can the convolutional neural network be used for training. The methods used to enhance the data set of the model described in this paper include color jitter, adjusting brightness and contrast, background removal and other methods to process images. The processed images are mainly set into three categories as input images for experimental comparison and testing the sorting accuracy of the model under different settings. The above three categories of image settings are 128 pixels in turn×128 pixels, 256 pixels×256 pixels and 512 pixels×512 pixels. In order to ensure that the model can accurately extract and learn the target information of the designated area according to the instructions during the experiment, image background removal technology is used to eliminate the noise information in the graphic information.

As shown in Fig 3, the intelligent sorting model based on convolutional neural network described in this paper includes four layers: input layer, convolution layer, pooling layer and full connection layer. The model receives 10 pictures from the camera each time, and then sends the 10 pictures to the convolution neural network for calculation after standardization. Through convolution, pooling, down sampling, etc. of the convolution neural network, the best classification results are finally output and sent to the hardware. In order to reduce the amount of relevant calculation, the system chooses to use the single channel image data as the input of the convolution neural network. The output module corresponds to the female and male classification results of poultry seedlings. The activation function used by the convolution layer and the first fully connected layer is ReLU. The activation function used in the output layer is SoftMax, which is commonly used for sorting.

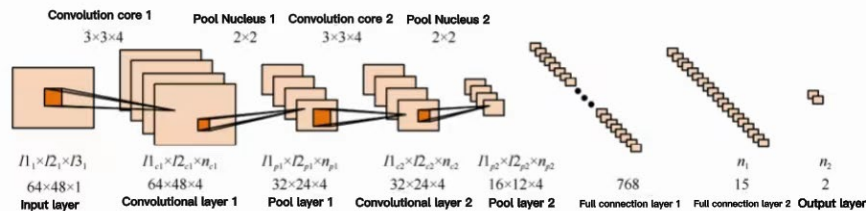


Figure 3: Convolution neural network structure model

5. Experimental results and analysis

According to the intelligent bird seedling sorting model based on convolutional neural network, in order to obtain the most appropriate image data input size, data sets with different resolutions are used for training to obtain the appropriate input size. After many experiments, the experimental results are as follows: (1) When the image input by the system is 512 pixels×512 pixels, the sorting and recognition accuracy is the best, and the accuracy of the result is 97.143%. (2) When the system inputs 128 pictures×At 128 pixels, the sorting recognition accuracy is 93.924%. In this case, the recognition time required for each picture is 0.326s. (3) When the picture input by the system is 256 pixels×The sorting and recognition accuracy of 256 pixels is 96.569%. In this case, the recognition time required for each picture is 0.364s.

According to the conclusions obtained from the above experimental data, it can be found that when the resolution of the image data input into the system is set to be lower, the recognition of the image data takes less time and is faster, but the accuracy of the bird seedling recognition is also lower. The reason

for this situation is that when the resolution of image data is set to be lower, the image will be over compressed and lose part of the feature information, which will affect the system's incomplete learning of image data information in the training process.

Compare the results of the model in the above three resolutions. It can be concluded that when the system inputs 128 images×128 pixels to 256 pixels×At 256 pixels, the processing time of the model for each image data increases by 0.28, but in this case, the recognition accuracy of the model increases by 2.645%. When the resolution of image data is increased to 512 pixels×At 512 pixels, the processing time of the model for each image data increases by 0.221, but in this case, the sorting and recognition accuracy of the model only increases by 0.565 percentage points. Therefore, considering various factors, the model selects 256 pixels as the input image×256 pixels can better ensure the identification accuracy and effectiveness of sorting.

6. Conclusion

Aiming at a series of problems existing in the sorting module in the process of poultry seedling breeding, such as high labor cost, high epidemic prevention requirements and health and safety level requirements, an intelligent poultry seedling sorting system based on convolutional neural network is designed. The system realizes the automatic sorting of the poultry seedling sorting module through the significant differences between male and female poultry seedlings, such as feathers, nostrils, feather color, etc. A sorting method combining visual technology to collect image information and convolutional neural network is proposed to identify male and female chicks efficiently and accurately, which is conducive to saving breeding costs and increasing business income for breeding hatcheries and poultry farms.

Build a simple model for sorting male and female poultry seedlings. In order to give consideration to the accuracy of the system in sorting male and female poultry seedlings and the speed of recognition of poultry seedlings, 256 pixels are selected through multiple experimental comparisons×256 pixel input image data can meet the accuracy and real-time requirements of system operation to the greatest extent. Through the specialized information collection of the poultry seedling characteristic information department and the establishment of the specialized database, the accuracy of the poultry seedling sorting can be improved to a greater extent. Considering the sorting production requirements and original energy consumption costs of relevant poultry breeding farms or incubators, the system only uses R channel to train convolutional neural networks. The accuracy of sorting and identification of male and female chicks can reach 97.8%.

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