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Research on Abnormal Behavior Detection Technology for Simmental Cattle

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Abstract: This paper mainly studies the abnormal behavior detection technology of Simmental cattle, aiming to establish an efficient and reliable abnormal behavior detection system, so as to detect abnormal situations in time and take corresponding measures to deal with potential problems. At the same time, by establishing a dataset for the abnormal behavior of Simmental cattle, the study uses deep learning algorithms to accurately capture the existence, location and key body parts of Simmental cattle, and accurately identify abnormal behaviors such as convulsions and falls. The application of abnormal behavior detection technology to animal husbandry to achieve contactless, automated, and efficient monitoring of Simmental cattle behavior can provide advanced and comprehensive intelligent health management solutions for animal husbandry and promote the wide application of intelligent management in animal husbandry. Real-time monitoring, early warning and fine management of Simmental cattle behavior can effectively reduce the risk of disease transmission and improve the production safety of farms.

Keywords: Computer Vision; Animal Husbandry; Simmental Cattle; Abnormal Behavior Monitoring; Intelligent Health Management.

1. Research Background and Implications

This paper explores how to apply abnormal behavior detection technology to Simmental cattle behavior monitoring, and to improve the status of animal husbandry management by establishing an efficient and reliable abnormal behavior detection system to realize real-time monitoring, early warning and fine management of Simmental cattle behavior status. In recent years, with the development of animal husbandry and the application of modern breeding technology, how to improve breeding efficiency and reduce the risk of disease transmission has become an urgent problem for animal husbandry managers. In livestock farms, Simmental cattle, as an important breed of beef cattle, has attracted widespread attention due to its excellent meat quality and rapid growth. At the same time, Simmental cattle are also widely distributed in various parts of Xinjiang, such as Korla, Aksu, Kashgar and other regions. At present, the number of Simmental cattle in Xinjiang has reached 975,800, and the annual number of slaughters is about 250,000 [1]. The breeding scale and output of this species are large, which has played an important role in promoting the development of local animal husbandry.

Traditional animal husbandry monitoring relies mainly on manual inspections, which is costly, inefficient and difficult to monitor around the clock. With the continuous development of deep learning and computer vision technology, animal behavior recognition and anomaly detection based on image and video data are one of the effective means to realize the intelligent management of animal husbandry. For example, deep learning algorithms are used to monitor and identify cattle behavior. In addition, several studies have explored early warning systems for abnormal cattle behavior, providing targeted solutions. However, the current research on the detection of abnormal behavior in Simmental cattle is still limited, and no mature solution has been formed. After improving the abnormal behavior dataset of Simmental cattle, combined with the intelligent identification technology of cattle, a Simmental cattle abnormal behavior detection system based on deep learning was established, which can provide more reliable and practical solutions for farms. It can realize the real-time monitoring of the behavior changes of Simmental cattle by farm breeders, and quickly take appropriate measures to deal with potential problems, as shown in Figure 1, which will minimize the impact of abnormal behavior on Simmental cattle and farm economic benefits, improve the production efficiency and profitability of the farm, and provide more reliable decision support and refined management tools for the breeding industry in a timely manner.

A Lying down

B Fights

Fig 1. Different behaviors of cattle

2. Research Status at Home and Abroad

The monitoring and identification of abnormal behavior of cattle based on computer vision has received extensive attention and in-depth research at home and abroad, and the main goals are to improve the production efficiency of animal husbandry, improve animal welfare, and strengthen the management of breeding environment.

At present, the animal behavior analysis system on the farm has applied a variety of intelligent technologies, and an innovative behavior recognition and computing scheme (BRCS) has been adopted in Europe and the United States, which can collect and analyze the behavior data of cattle by obtaining information through microchips swallowed by cattle [2]. In addition, image processing and deep learning were used to accomplish target localization and behavior recognition, which showed an accuracy rate of more than 80% in the reproductive health of dairy cows, especially in the recognition rate of hoof disease and heat, while the false negative rates of heat and hoof disease were 3.28% and 5.32%, respectively [3]. Some research institutions have proposed a lightweight network structure based on feature fusion, and applied a new trajectory behavior analysis method in walking and standing, so that the algorithm can achieve the best performance in terms of accuracy and generalization ability [4]. The application of these technologies can help farmers to detect the health problems of their cattle in a timely manner and take corresponding measures to treat and prevent them, thereby improving the efficiency of the farm and the quality of dairy products.

In China, animal husbandry research institutions and agricultural science and technology companies actively promote the research and practical application of cattle abnormal behavior monitoring technology. For example, in the research of dairy cow behavior recognition and health monitoring, methods based on inertial navigation sensors and machine learning technology [5] are used to use machine vision to identify and time statistics various daily behaviors of cattle to meet the needs of farms. With the widespread implementation of agricultural intelligence in China's farms, machine vision technology plays a key role in this process, helping farmers understand the status of cattle in real time. In addition, the OpenPose model based on human pose estimation was used to improve the pose estimation of dairy cows by using transfer learning methods, and the T-OpenPose model was constructed, and the position information of all key body parts of dairy cows in video images was obtained[6]. At the same time, studies have also shown that the CNN-LSTM model has an accuracy of 96.0% for the four behaviors of dairy cows: standing, lying on the stomach, eating, and walking, which is 6.1% and 4.9% higher than that of the CNN model and the LSTM model respectively [7].

Both domestic and foreign countries attach great importance to the monitoring and recognition technology of abnormal cattle behavior based on computer vision, and pay special attention to its application potential in the development of animal husbandry. These technologies have made a positive contribution to the intelligent, efficient and sustainable development of animal husbandry.

3. Difficulties and Challenges of Behavior Detection in Simmental Cattle

First, the collection and labeling of abnormal behavior data in Simmental cattle is an important challenge. In order to construct an accurate abnormal behavior model, large-scale Simmental cattle behavior data is needed, and obtaining high-quality data and accurately labeling it requires a lot of time and human resources. Secondly, the diversity of abnormal behaviors is also a challenge. Abnormal behaviors of different Simental cattle are diverse, including exercise, eating, rest and social behaviors, etc., so it is necessary to establish several different detection models and elaborate classification. In addition, the complex farm environment also increases the difficulty of technology application. There are various interference factors in the farm environment, such as noise, light changes and temperature fluctuations. Meanwhile, the video abnormal behavior detection algorithm needs to model the appearance and motion characteristics of normal events, but it also faces problems such as occlusion and category imbalance in surveillance videos [9]. These factors may affect the accuracy of abnormal behavior detection, thus increasing the difficulty of algorithm design and optimization. In order to meet the real-time and automated task of abnormal behavior detection of Simmental cattle, in addition to accurate monitoring and analysis of cattle behavior, it is also necessary to quickly respond to abnormal events, requiring continuous monitoring and analysis of cattle behavior, timely detection of abnormal situations, and automatic triggering of early warning and treatment measures. The second is fine management, through the detection of abnormal behavior, can help farmers targeted management and intervention, so as to improve the efficiency of farming. The application of this technology helps to improve the efficiency of animal husbandry, including improving production efficiency, reducing the risk of disease transmission, improving the living conditions of Simmental cattle, promoting the sustainable development of animal husbandry, and achieving the goal of human-animal symbiosis, so it is very necessary to explore.

4. Implementation of Abnormal Behavior Detection in Simmental Cattle

The abnormal behavior detection model based on deep learning continuously improves the accuracy and robustness of the model during iteration and optimization, and analyzes the detection of different abnormal behaviors by evaluating key indicators such as its accuracy and recall rate. If the evaluation results do not meet the requirements, the model should be found to improve and optimize the model. After the model evaluation is completed, the system application and experimental verification are carried out. Abnormal behavior detection based on computer vision can effectively realize the intelligent monitoring and management of cattle behavior, and provide ideas and solutions for the development and sustainability of animal husbandry.

In order to realize abnormal behavior detection of cattle, it is necessary to comprehensively consider the characteristics of Simmental cattle behavior, data acquisition, algorithm design and real-time requirements, so as to establish an accurate and reliable abnormal behavior detection system of

Simmental cattle through continuous iteration and optimization. Therefore, abnormal behavior detection of Simmental cattle faces the following key problems:

(1) Abnormal behavior definition: Determine what is abnormal behavior and deeply understand the behavior characteristics of Simmental cattle.

(2) Build the data set: determine the data acquisition method, sensor and annotation method.

(3) Feature extraction and selection: Select the appropriate feature extraction method, and select the most discriminative feature based on the learning method.

(4) Anomaly detection algorithm: Select machine learning or deep learning algorithm, and conduct model training and tuning.

(5) Real-time monitoring and response: Continuous monitoring and analysis of cattle behavior, rapid response to abnormal events.

As shown in Figure 2, target detection technology, posture estimation technology and behavior recognition technology are mainly used to realize the monitoring and management of cattle. To build an efficient cattle anomaly behavior detection model, it is necessary to collect a large amount of Simmental cattle behavior data. This data should cover cattle behavior at different times, in different environments, and from different perspectives. At the same time, it can also be combined with public datasets to increase the diversity and generalization ability of training data. Perform in-depth analysis of the collected data. Annotate the key points of the cattle body image, such as the position of each key point such as the cow head, torso, limbs, etc., and build a bone key point detection model. Then, a behavior recognition model was constructed, and the data of time series modeling were mapped to different action categories based on the results of cattle body key point detection, so as to achieve accurate recognition of cattle behavior. In order to further improve the accuracy of the model and realize the lightweight of the model, the accuracy and real-time performance of the bovine pose estimation model can be further improved by introducing deeper neural network architecture, improving pose representation, joint optimization task, and reducing computational complexity, so as to meet the needs of more practical application scenarios.

In order to enhance the generalization of the detection model, data augmentation methods such as geometric transformation and color transformation can be used. Geometric transformation increases the diversity of data and the robustness of the model by random cropping, scaling, rotation, flipping and other operations, while color transformation can change the appearance of the image by adjusting the brightness, contrast, color balance, etc., so as to improve the ability of the model to adapt to the detection of cattle behavior under different environmental conditions. In addition, generative adversarial networks (GANs) can be used to generate synthetic bovine behavior data to help the model learn more bovine behavior patterns and improve generalization ability. Another effective data augmentation method is Mixup, which can linearly interpolate the features and labels of different samples to generate new samples and further improve the generalization ability of the model. By enriching and transforming the original data, the diversity and quantity of training data are increased. In Simmental cattle abnormal behavior detection technology, random rotation, flipping, cropping and occlusion methods can be used to simulate the changes of animal behavior in real scenes, so as to improve the generalization ability and robustness of the model. This diversity helps the model to better adapt to abnormal behavior from different viewing angles and background conditions.

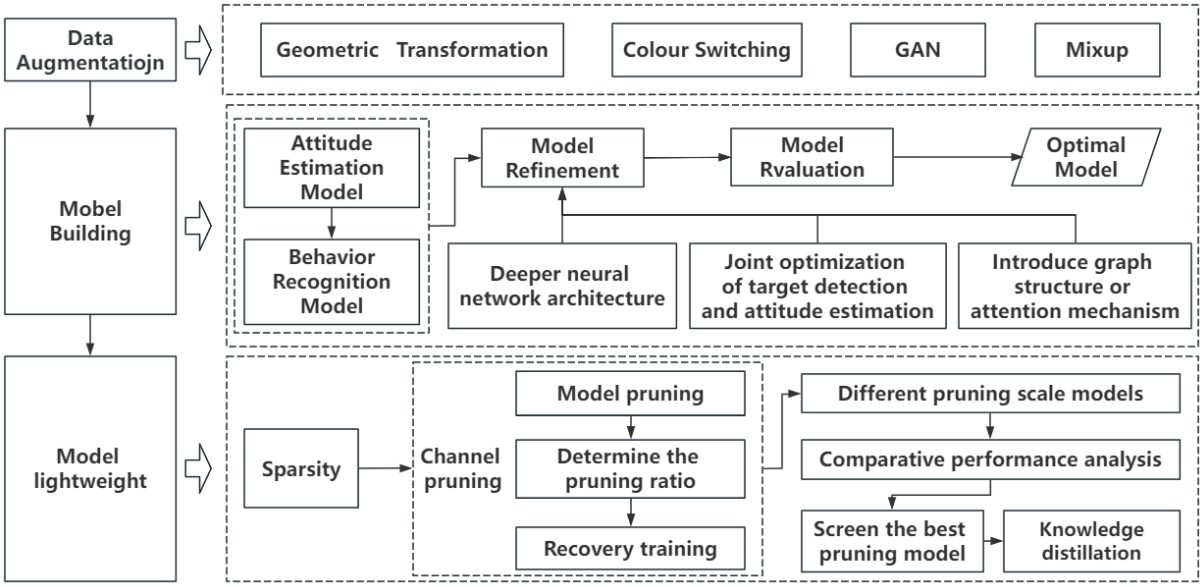

Fig 2. Technical route of cattle abnormal behavior detection

In terms of model improvement, the use of advanced neural network structures, such as deep residual networks and attention mechanisms, can improve the representation and perception capabilities of the model. The introduction of attention mechanism and spatiotemporal modeling methods can capture the key information of animal behavior more accurately, and improve the accuracy and robustness of abnormal behavior detection. This improvement allows the model to identify and classify a variety of anomalous behaviors more effectively. In addition, there may be some shortcomings in the existing pose representation methods, such as insufficient modeling of the association information between joints, unclear joint rotation constraints, etc., and the improvement direction can consider introducing graph structure or attention mechanism to better describe the dependence between joints, and design more reasonable

constraints to optimize the coherence and interpretability of pose representation. At present, YOLO-Pose and other algorithms perform object detection and then pose estimation, and the joint optimization of object detection and pose estimation tasks can be considered to improve the comprehensive performance of the two tasks by sharing the feature extraction layer and multi-task learning.

In practical applications, hardware resources and computing power may be limited, so the model needs to be lightweighted. This includes techniques such as pruning, quantification, and distillation. Pruning simplifies the model structure by removing redundant network connections and parameters. Quantization compresses model parameters to low-precision representations, reducing storage space and computational overhead. Distillation technology, on the other hand, allows the transfer of knowledge from a large model to a small model, reducing the size of the model while maintaining performance. This lightweight processing makes the Simmental abnormal behavior detection model more suitable for deployment in resource-constrained environments, maintaining its efficiency and real-time performance.

In summary, abnormal behavior identification can be realized by establishing a Simmental cattle behavior data set and adopting computer vision and deep learning technologies. The data of different behaviors of Simenthal cattle were collected, and the data were labeled and processed to identify the behavior type corresponding to each data. Livestock Vision and COCO datasets were introduced to further improve the accuracy and comprehensiveness of the dataset. The target detection algorithm is used to accurately extract the cattle region, which provides the basis for the following steps. Key point detection technology is used to identify the key parts of Simenthal cattle, such as head, leg, etc., to provide more detailed pose information, and facilitate the modeling and classification of Simenthal cattle movements. Then, combined with the action classification model, we can judge whether the current behavior is abnormal and give early warning in time. Finally, the abnormal behavior detection model with low requirement of computing power and storage resources is obtained by using model compression technology. As shown in Figure 3, the abnormal behavior detection system relies on the basic support layer including abnormal behavior detection model, NCNN library, image processing library, and cattle behavior data set to detect abnormal cow behavior in the input image, and output abnormal behavior and cattle location information and confidence.

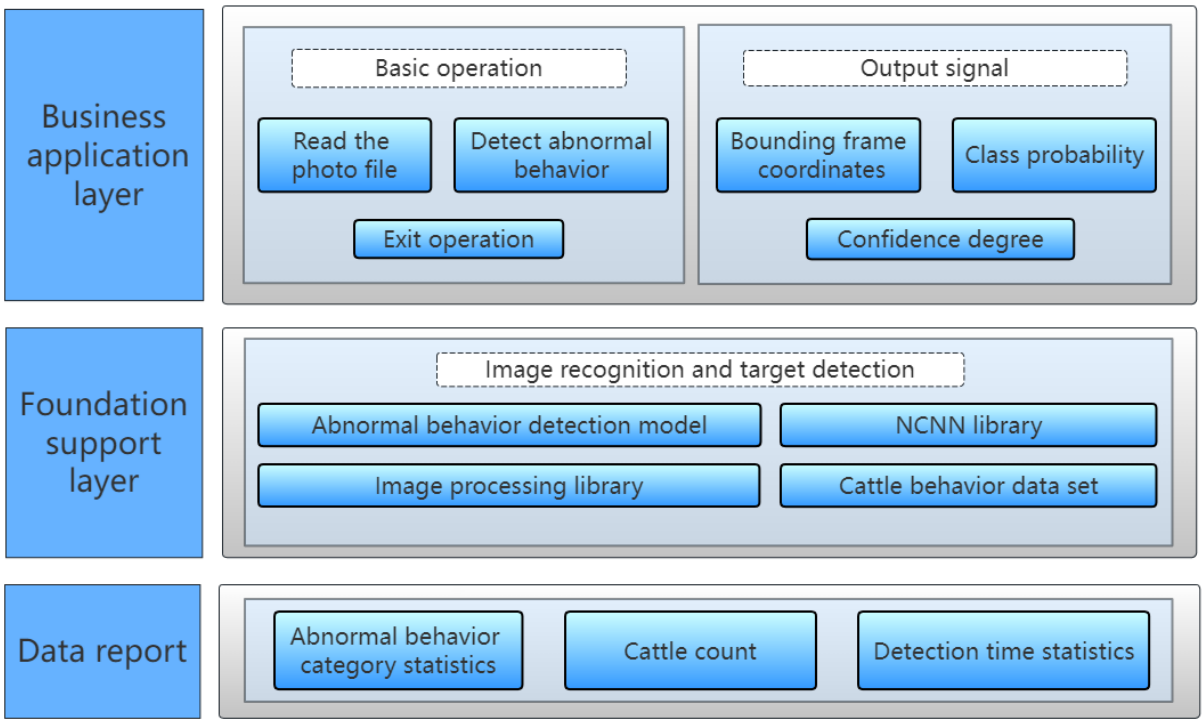

Fig 3. Framework diagram of cattle abnormal behavior detection system

5. Application Scenarios and Future Prospects

5.1. Application Prospect of Simmental Cattle Abnormal Behavior Detection Technology in the Field of Animal Husbandry

Detection technology based on computer vision is currently one of the more advanced technologies in the field of animal husbandry, and the application prospects are very broad. The following are the main application prospects of abnormal behavior detection of Simmental cattle in the field of animal husbandry:

(1) Disease early warning and health management: Through real-time monitoring and identification of abnormal behavior of cattle, signs of disease can be detected at an early stage, early warning can be given and corresponding measures can be taken, so as to safeguard the health of livestock animals.

(2) Optimization of feeding management: using abnormal behavior detection technology, cattle feeding behavior can be monitored and analyzed to optimize feed supply, feeding time and mode, and improve feeding efficiency and health status.

(3) Reproductive management: Monitoring the reproductive behavior of cattle, such as estrus and mating behavior, to help improve reproductive efficiency, predict the time of conception, and optimize breeding programs.

(4) Animal Welfare Guarantee: through monitoring and

identifying abnormal behavior of cattle, timely detection of whether they are injured, in pain, or otherwise unwell, and appropriate intervention to enhance animal welfare

(5) Farm management optimization: Combined with other agricultural intelligent technologies, such as Internet of Things and data analysis, abnormal behavior detection technology can realize real-time monitoring, data collection and analysis of farms, optimize management decisions, and improve economic efficiency and sustainable development.

5.2. Possible Expansion of Application Fields

In addition to the field of animal husbandry, Simmental cattle abnormal behavior detection technology has some expanded application fields, including but not limited to the following aspects:

(1) Home farming: Simmental cattle abnormal behavior detection technology can be applied to other livestock breeding, such as horses, chickens, pigs, etc. By monitoring and identifying abnormal behavior of domestic animals, problems or anomalies can be detected in time and corresponding measures can be taken.

(2) Zoo management: Zoos often need to monitor and manage the behavior of animals. Simmental cattle abnormal behavior detection technology can help zoos monitor animal behavior and detect abnormalities, such as fighting, illness, external interference, etc., so as to intervene and warn in time.

(3) Laboratory animal studies: In laboratory animal studies, Simmental cattle abnormal behavior detection technology can be used to monitor the behavior patterns of laboratory animals, such as activity, eating, sleeping, etc. Through the real-time monitoring and analysis of the behavior of experimental animals, their psychological state and physiological changes can be understood, which provides support for the accuracy of experimental results.

(4) Bioengineering: Combined with the abnormal behavior detection technology of Simmental cattle, the behavioral performance of animals can be evaluated, which helps to preferentially select and screen individuals with good behavioral traits, providing strong support in the field of bioengineering.

(5) Wildlife protection and research: Simmental cattle abnormal behavior detection technology can be used in the field of wildlife protection and research. Through the deployment of monitoring equipment in the natural environment, real-time monitoring of the behavior and action patterns of wild animals, and then understand their range of activities, habits and behavioral changes, providing data support for wildlife protection and ecological research.

In summary, the abnormal behavior detection technology of Simmental cattle is of great significance and great potential. Through technologies such as deep learning and computer vision, accurate monitoring and analysis of cattle behavior can be achieved. This is of great significance for health management, disease early warning and production efficiency improvement in the livestock industry. The analysis of behavioral data for Simmental cattle can also provide scientific feeding management suggestions for farms. In terms of application areas, the technology is not only suitable for large-scale farms, but can also play a role in family farming, zoo management, laboratory animal research, bioengineering and wildlife conservation and research. It provides a more accurate and efficient means for animal management and protection, and promotes the development and progress of related fields.

In conclusion, the technology for detecting abnormal behavior of Simmental cattle has great potential for application. With the continuous progress of the technology and efforts to solve the challenges, it is believed that the technology will play a greater role in the field of animal husbandry and promote the healthy development of animal husbandry.

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