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COWOZE - AN AUTOMATED ESTRUS DETECTION SYSTEM

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Abstract: The evolution in the agricultural field has assisted modern livestock industry to raise up the scale which results in requisite for the management of cow breeding. To breed the cow, monitoring the estrus behavior is one of the important tasks. Estrus commonly addressed "heat". Estrus refers to the progenitive phase of cattle during which ovulation occurs. This is the crucial stage of the reproductive life of cows. During ovulation, artificial insemination is carried out in dairy farms by farmers. The conventional approach to find the phase of estrus is by attaching an electronic device to the cow. This device makes the cow feel uneasy. To overcome this Cowoze is designed. The main goal of this study is to detect the cow in estrus or non-estrus state by using a deep learning algorithm-based approach. Cowoze takes a sequence of images as input. It analyzes the estrus behaviors of cows and helps farmers to recognize cows in estrus phase. This model detects the cows, it's body parts and estrus behavior of cows by extracting a set of discriminative features. The model detects the estrus of cows with an accuracy of 99%.

***Index Terms* - Estrus detection, Dairy cows, Image Processing, Deep Learning Algorithm.**

I. INTRODUCTION

In dairy farms, cows do not get pregnant naturally, as female and male cows are raised separately in farms. Thus, artificial insemination is required. Cows must be inseminated at an appropriate stage, which is in the time of estrus cycle. Estrus refers to the progenitive phase of cattle during which ovulation occurs. This is the crucial stage of the reproductive life of cows. Estrus commonly addressed as "heat". The length of the estrus is 21 days. The estrus cycle can be classified into 4 stages. That is Proestrus (lasts for 0-4 days), Estrus (lasts for 4-5 days), metestrus (lasts for 5-8 days) and diestrus (lasts for 9-21 days). At the phase of estrus, the cow ovulates and is ready to get inseminated. The incubation period of the ovulated egg is short, it's around 18 - 24 hours. The egg will be in a fertile state after ovulation, which is the appropriate time to inject semen. So, it is necessary for an accurate detection of heat. If a farmer fails to bring their cows for insemination, then they have to wait till the next cycle.

The traditional approach uses humans to recognise the sexual receptive behaviors in cattle. These behaviors include – (1) Mounting also called "standing estrus". (2) Sniffing and chin resting on other cows and (3) Swollen vulva and mucus discharge. Farmers may miss out on these signs if he does not notice these signs with conscious. If in the estrus in cows aren't detected in applicable time and get inseminated or if cows are falsely recognised as being in estrus, fewer calves will be born, and accordingly milk production will decrease.

To overcome these disadvantages of traditional approaches, automated electronic detection systems have been designed and developed. It consists of an electronic patch which is fixed to the cow and it wirelessly sends data to a system which processes data to detect mounting behavior. It annoys the cow and is also expensive to afford in large farms. These are the two drawbacks of this system. Other than these there are other devices as well to detect estrus, such as, mounting activity detector, pedometer, and accelerometer. Therefore, to overcome all these disadvantages, we designed an automated estrus detection system that depends only on the camera and a computer. It takes a sequence of images as input and analyzes the estrus behaviors of cows using a deep learning algorithm-based approach. Even though some literature has used machine learning and computer vision techniques to detect estrus in cows [2-3], it considered only the primary visual sign by ignoring secondary visual signs. The first attempt was made by CowXNet: An automated cow estrus detection system [1] in detecting the estrus in cows using machine learning algorithm and computer vision attained an accuracy of 99%. To increase the accuracy and to be more efficient we designed this system.

Our main contributions are:

A. An estrus detection system using computer vision and machine learning techniques.

B. A classification feature that leads to 99% accuracy for predicting cow behavior.

II. RELATED WORKS

Complete details of animal behavior analysis are found [4-6]. In addition to that, animal behavior is detected and analyzed automatically. [7] gives information on a non-wearable depth-based tracking system for recognising behaviors automatically (behaviors like sitting, moving are recognised using classification algorithms by extracting the information from the video). [8] also made use of videos, they captured and analyzed the motion of rodents.

In one study [9], discovered a deep learning-based monitoring method to identify rumination behavior of cows in frame. They've not used any electronic device attached to the animal which could have a bad influence on behavior of cows and it meets the accuracy of 95%.[10] also proposed a computer vision-based system, which detects disabilities in cattle and achieved accuracy of 90%. In another study [11], presented a deep learning technique to identify color changes in a heat detector device which monitors the cows in estrus. A device was attached to the tail base of the cow. The heat detector changes its color when the cow is mounted on another cow. This was highly effective and achieved an accuracy >90%. Nevertheless, it was not that effective, when some cows show behaviors other than mounting, like sniffing and motion patterns. When compared, our method overcomes this loophole with the same accuracy. CowXNet: An automated cow estrus detection [1] detects the estrus phase in cows with an accuracy of 83%. They used YOLOv4 for the real time object detection. Whereas in our system we used YOLOv5 for object detection and we achieved an accuracy 99%. Several papers demonstrate the animal behavior including estrus. But we tried to analyze estrus using visual data.

III. DATASET

In our study, we use a sequence of images to train the model to detect the estrus phase in cows. The data is collected from a Chokchai Farm, Khao Yai, Thailand. This is one of the biggest dairy farms in Asia. The experts from Chokchai Farm physically detected the three Holstein Friesian cows in estrus by noticing their behaviors. The cows were four years old and 450kg. A camera was placed at the top-view position. The camera was connected to a personal computer via a USB cable: it captured videos at 1.5 frames per second. Each image was a 24-bit RGB image with 1280x960 pixels and stored in Tagged Image File Format (TIFF). The total of 2200 images are extracted from the video which is loaded into the model to train it. From this sequence of images, a feature is extracted to detect the estrus in cows.

IV. IMPLEMENTATION

Our system used a number of computer vision techniques. object detection and detection of key points by means of machine learning algorithms. Cowoze has been designed to help cow producers detect the presence of estrus so they can move it for insemination at the right time. It comprises four modules: (i) detection of cows, (ii) detection of body parts, (iii) detection of estrus behaviour and (iv) analysis of behaviour.

4.1 Detection of cows

Firstly, the cow must be detected in the dataset with convolution neural network (CNN). YOLO is an acronym that stands for You Only Look Once. Using convolutional neural network (CNN) for objects in real-time with great accuracy. We use version 5, one of the most advanced object detection algorithms. This approach uses a single neural network to process the whole image, then separates it into parts and predicts bounding boxes and probabilities for each component. These bounding boxes are weighted in accordance with the expected probability. The results of the detection module include the cow locations in each frame. Once all cows were detected, a cropped image of each cow was created and used in the next body part detection module. The model is trained using transfer-learning where the cow is detected in frame as shown in Fig. 4.1. This module attains an accuracy of 99%.

Fig. 4.1. cow detection

4.2 Detection of body parts

Cows frequently use their bodies to communicate with each other in estrus. Therefore, the location of body parts will help us to analyze the behavior of the estrus. Key point detection recognizes and locates the key points of objects in an image. The body part detection module was designed to detect the body parts of the cows that were detected. We examined three body parts: the nose, body and base of the tail (tail-head), which were used to monitor each cow's movement through a pen. Also, during estrus, cows make physical contact using these body parts, such as mounting, sniffing, butting heads and resting their chins on the hips of others. Cartesian coordinates (x, y) are used to represent each body part's location. Using a key-point estimator, a regression task can obtain coordinates. Thereafter detected body parts are passed to the next module to extract discriminative features that indicate estrus behaviour. The key-points of each cow in the frame are detected and the coordinates are recorded as shown in the Fig. 4.2. This module attains an accuracy of >90%.

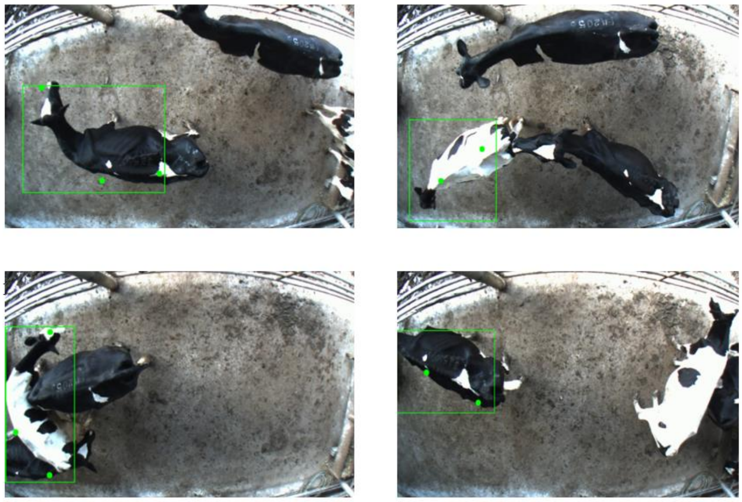

Fig. 4.2. key point detection

4.3 Detection of estrus behaviour

This module recognises and returns a binary value, with or without estrus by using recorded coordinates, the key-points stored in Comma Separated Values (CSV) file. In order to achieve this, we have detected one of the distinctive features for cows in estrus. The main features extracted in our model is chin resting on other cow and sniffing. The CSV file is then passed to a XgBoost classifier to analyze the behavior of each cow individually. This module attains an accuracy of 99%.

4.4 Analysis of behaviour

This module is the extension of the former module. When a sequence of images is passed as an input, behaviour of every cow in the frames are analyzed. Based-on the analysis the system predicts the estrus cow and non-estrus cow as illustrated in the Fig. 4.4. This module achieves up to an accuracy of 99%.

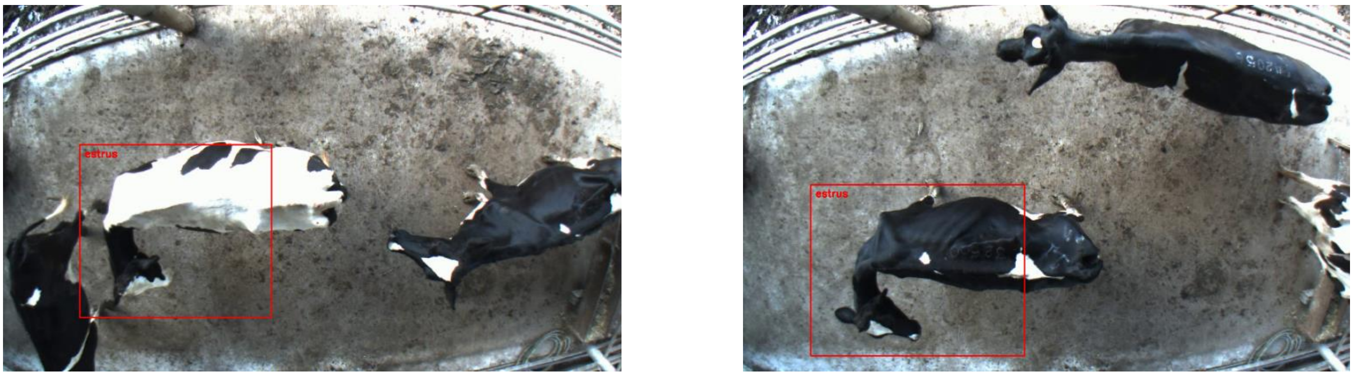

Fig. 4.4. behaviour analysis and estrus detection

V. RESULTS

Result is analyzed on the basis of module independent evaluation and end-to-end framework evaluation. Module-Independent Evaluation - Here, the results are evaluated module wise and the accuracy is checked. End-To-End Framework Evaluation - All the modules are interdependent, that is, output of each module is passed as an input for the next module. Whole system is evaluated at once and output is predicted. Fig. 5.1 shows the confusion matrix where it summarizes the performance of the model based on the test data. In this matrix the 0 represents the non-estrus values and 1 represents the estrus value. By looking at actual and predicted values we have achieved accuracy up to 99%.

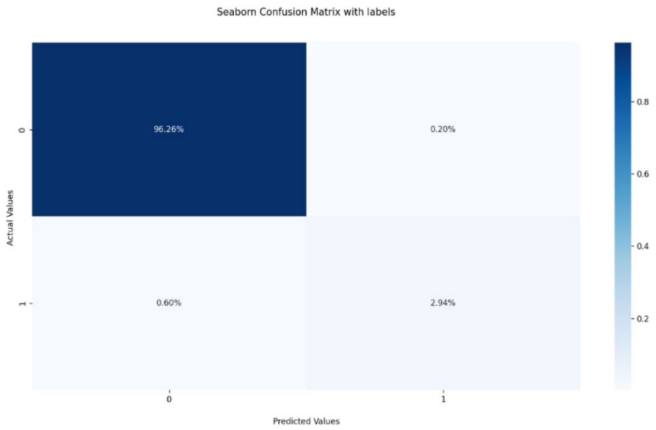

Fig. 5.1. confusion matrix

VI. CONCLUSION AND FUTURE SCOPE

We proposed an automated estrus detection system for cows. This helps dairy farm owners to recognize the cows which are in the estrus phase. Our system completes the task of identifying the estrus cows without any human observation or electronic patch attached to its body which causes uneasiness. We have designed a system which consists of four modules that are – 1. Cow detection 2. Body-part detection 3. Estrus behavior analysis and 4. Behavior analysis. The input is in video format and these are converted to frames and cow in frame gets detected. Later, key-points (i.e., tail-head, hip and head) are marked and the coordinates are recorded. These coordinates are passed to the XgBoost classifier to analyze the behavior of cows and predict the result. Our system achieved an accuracy of around 99%.

The limitation of this model is, model is not trained to identify the cows which undergo silent estrus (i.e. cows which don't show any behavior while undergoing estrus phase) and model is trained only using aerial view images, it might fail in identifying the estrus when video in other view is taken as input. This is considered for future work. We believe that this might help other researchers to continue the work.

REFERENCES

[1] Thanawat Lodkaew, Kitsuchart Pasupa, Chu Kiong Loo, "CowXNet: An automated cow estrus detection system", 2022.

[2] S. M., Zin, T. T., Tin, P., & Kobayashi, I. (2022). Automatic detection and tracking of mounting behavior in cattle using a deep learning-based instance segmentation model. International Journal of Innovative Computing, Information and Control, 18, 211–220.

[3] Heo, E.-J., Ahn, S.-J., & Choi, K.-S. (2019). Real-time Cattle action recognition for Estrus detection. *KSII Transactions on Internet and Information Systems*, *13*(4), 2148–2161.

[4] Breed, M. D., & Moore, J. (2021). *Animal behavior*. Academic Press.

[5] Dugatkin, L. A. (2020). *Principles of animal behavior*. University of Chicago Press.

[6] Ferster, C. B. (1966). Animal behavior and mental illness. *The Psychological Record*, *16*(3), 345–356.

[7] Pons, P., Jaen, J., & Catala, A. (2017). Assessing machine learning classifiers for the detection of animals' behavior using depth-based tracking. *Expert Systems with Applications*, *86*, 235–246.

[8] Pennington, Z. T., Dong, Z., Feng, Y., Vetere, L. M., Page-Harley, L., Shuman, T., et al. (2019). ezTrack: An open-source video analysis pipeline for the investigation of animal behavior. *Scientific Reports*, *9*(1), 1–11.

[9] Ayadi, S., Ben Said, A., Jabbar, R., Aloulou, C., Chabbouh, A., & Achballah, A. B. (2020). Dairy cow rumination detection: A deep learning approach. In *Proceedings of the international workshop on distributed computing for emerging smart networks* (pp. 123–139). Springer.

[10] Kang, X., Zhang, X., & Liu, G. (2020). Accurate detection of lameness in dairy cattle with computer vision: A new and individualized detection strategy based on the analysis of the supporting phase. *Journal of Dairy Science*, *103*(11), 10628–10638.

[11] Chowdhury, S., Verma, B., Roberts, J., Corbet, N., & Swain, D. (2016). Deep learning-based computer vision technique for automatic heat detection in cows. In *Proceedings of the 2016 international conference on digital image computing: techniques and applications* (pp. 1–6). IEEE.