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Research Paper

Region detection of lesion area of knee based on colour edge detection and bilateral projection

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Wear of the knee is an important indicator of the health status of dairy cows. However, the complex cattle environment and the presence of mud, excrement, and other interferences make examination of the lesion area difficult. We utilised a region detection method based on colour edge detection and bilateral projection to detect the knee area of cows. First, edge information of colour images was obtained by colour edge extraction. Second, most of the background was removed and the leg region was obtained using an open operation, vertical projection, and convex hull processing. Finally, threshold processing and horizontal projection were applied to determine the centre of the target region and the overall target region. To verify the validity of the proposed algorithm, a K-means algorithm and salient region detection were performed. In total, 81 test samples were randomly selected from 300 images, and the results showed that the average overlap rate (OR) was 6.5% and 17.3% higher than that of the K-means and saliency methods, respectively. The false-positive rate (FPR) was 0.8% higher than that of the K-means method and 6.2% lower than that of the saliency method, and the false-negative rate (FNR) decreased by 6.5% and 17.3%, respectively. The present method showed good robustness when background obstructions or ground reflection was present in the images. The results of the present work imply that our method can effectively extract the target region and could stimulate further analysis of cow knees containing swelling and scars.

1. Introduction

With the development of large-scale farming of cows, accurate breeding based on information technology has become important for improving scientific management and increasing the production efficiency of cows (He, Liu, & Zhao, 2016). Dyskinesia is a main factor affecting production in cow breeding (Huang, 2012). von Keyserlingk, Barrientos, Ito, Galo, and Weary (2012) found that joint injury can be regarded as a nascent factor leading to animals' dyskinesia and that wear of the knee of cows is mainly derived from repeated abrasions when rising and kneeling. Lim et al. (2014) scored joints according to their hair loss

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status. However, dairy farm-related factors such as excrement and occlusion made inspection more difficult. At present, scoring relies mainly on manual statistics (Heyerhoff et al., 2014), which wastes time and energy and is not conducive to intelligent management. Accurate detection of the lesion area of cows' joints not only provides information about a joint injury but is also of great significance for improved management of cows' health.

Computer image processing can extract an object region from a complicated background; it can also analyse and understand the image (Xiao et al., 2015). As a result, computer imaging has increasingly received more attention in the fields of agricultural object recognition (Tao, Zhao, Xi, Yu, & Wang, 2014; Xu & Lü, 2015) and disease detection (Ge, Shao, Ding, Li, & Zhao, 2008; Ren, Lu, Yuan, Xue, & Xu, 2016). In recent years, many achievements have been made in computer vision technology and image analysis, such as analysing animal behaviour and activity patterns. Zhu, Liu, Yang, and Ma (2015) adapted an active shape model for detection of the pig ear region. Zhao and He (2014) utilised a video technique to realise real-time monitoring of the motion status of all four limbs of cows, which greatly facilitated the identification of limping. Liu, Zhao, and He (2016) used the Gaussian mixture model to test moving cows. At present, computer analysis of cows is mainly performed using video analysis technology to extract the whole cow from its complex background (Zhao & He, 2015); detection of localised damage has not yet been reported. Local damage detection belongs to the field of region detection, and common methods of such detection include edge detection (Shen & Sheng, 2004), image clustering (Li, Wang, & Bian, 2010), and visual significance (Cheng, Zhang, Mitra, Huang, & Hu, 2015). Liu, Xia, Sang, and Qin (2014) segmented cotton impurity images using different edge operators. Li, Ma, Huang, Chi, and Wang (2010) used the K-means clustering method to detect diseased spots on grapes; however, this was not suitable for images with uneven illumination or complex environmental backgrounds. Based on image saliency, Ye, Lang, Liu, and Li (2016) identified regions of cucumber downy mildew, but these regions were easily disturbed by regions with a colour similar to that of the scab.

Analysis of the lesion area of the cow knee is the foundation for further examination of an abnormal knee. However, the complexity of the cattle environment and the presence of mud, excrement, lack of hair, scars, and similar factors make the examination of the lesion area difficult. The above-mentioned region detection methods are susceptible to interference from non-target regions, resulting in a larger segmentation error.

In this study, we combined colour edge detection and bilateral projection to create a novel method with which to examine the knee area of dairy cows. The objective of this study was to effectively extract the knee lesion area from a complex environment. We expect that the results will stimulate further testing of cow knees affected by swelling and scars.

2. Materials and methods

2.1. *Image acquisition*

The images were collected at the dairy farm of Keyuan Clone LLC in Yangling, Shaanxi from September 2016 to October 2016, on sunny days from 13:30 to 15:00. The surface of the exercise yard was covered by sandy soil, and the cows often knelt to rest; thus, the knees easily became worn, and long-term abrasion turned them into a soil colour. The region affected by the soil discolouration was therefore regarded as the lesion area. Images of the lesion area of the knees were taken with an EOS 550D digital camera. The shooting distance was 2 m, the lens focal length was 135 mm, the aperture was F2.8, the image size was 3456 × 2304 pixels, and the image was stored as a 24-bit JPEG file. Shooting scene is in Fig. 1.

When shooting, we excluded knees with obvious mud or excrement, and 81 images were randomly selected from a total of 300 images; representative samples are shown in Fig. 2. The target region included scars, soil, black hairs, and other factors. The background region usually included rails and sometimes ground reflection, waste, others cows' legs, and milking facilities.

2.2. *Data processing platform*

The computer data processor was an Intel Core I5-3210, and the basic frequency was 2.5 GHz, with 4 GB of memory and a 500 G hard disk. All tests were carried out under the environment of MATLAB 2012a.

2.3. *Lesion area detection using fusion colour edge detection and bilateral projection*

To detect the knee area of cows, the leg was first divided from a colour image based on the method of colour edge detection

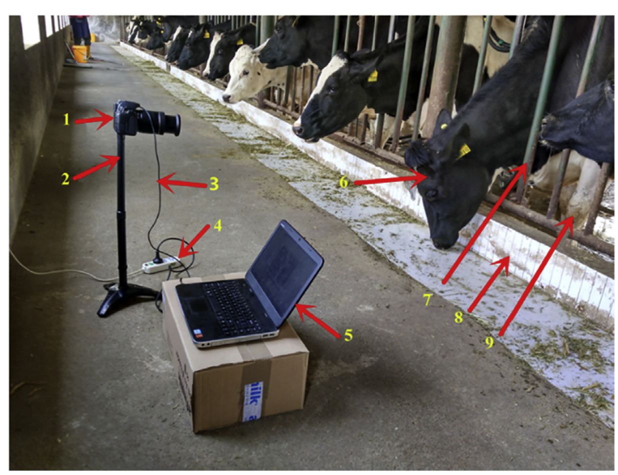

Fig. 1 – Shooting scene. (1) Camera, (2) Trestle, (3) Data lines, (4) Power supply, (5) Computer, (6) Target cow, (7) Parapet, (8) Ceramic tile, (9) Target region.

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