Abstract

Data on individual feed intake of dairy cows, an important variable for farm management, are currently unavailable in commercial dairies. A main issue in dairy farming is animal feed costs, however, as yet, cow individual feed intake cannot be measured in commercial farms. Since the variation of the feed consumption for different cows can reach 30% for similar milk yield and housing conditions, replacing inefficient cows and breeding more efficient cows can have economical value for farmers. Monitoring individual cow feed intake is necessary for calculating the cow individual feed efficiency. The cost and maintenance time necessary for research systems make them impractical for most of the commercial producers. Therefor, the goal of this study was to design the system and validate its ability to rank cows by their feed conversion efficiency in commercial farms.

Year 1 .A low-cost system for monitoring the cow individual feed intake was developed and tested. To make the system affordable for use in commercial farms, its design was focused on decreasing the system cost and maintenance time. In experiments, the system accuracy was found to be sufficient to recognize the most efficient and inefficient cows even with low-cost components and structure. The new system consisted of three principal parts: (a) a hanging weighing system fpr system calibration, (b) a visual cow identification system and (c) an 3D camera feed monitoring. The weighing system consisted of hanging a single load cell to provide feed mass measurements. The image-based cow identification system (replacing Radio-Frequency Identification) entailed cameras installed above the feeding area and an image processing algorithm that recognized cows by their collar numbers. The new system worked within normal farm routines: the feed supplying truck distributed the animal feed, and a tractor cleaned feed residual. To validate the accuracy and convenience of the system and to rank the cows by their efficiency, an experiment with six scales and 12 cows was conducted in a research barn, succeeded by eight-scale system in a commercial farm with 16 cows. The feed intake of each cow participating in the experiments was monitored for one month. The validation experiment showed that the system had the following specification: scales were accurate within 120 g; the visual cow identification rate was greater than 96%; feeding duration was accurate to 52 s; and routine farm practices (feed distribution, pushing, and residual removal) continued as usual. The cost for a feeding station (utilized consequently for a number of cows) was about 1500 USD. An example of application of the system to rank cows by their efficiency under commercial conditions was shown. The system can potentially be used for ranking cows by their efficiency in commercial facilities.

Year 2. A real-time machine vision system including models that are able to adapt to multiple types of feed was developed to predict individual feed intake of dairy cows. Using a Red-Green-Blue-Depth (RGBD) camera, images of feed piles of two different feed types (lactating cows' feed and heifers' feed) were acquired in a research dairy farm, for a range of feed weights under varied configurations and illuminations. Several models were developed to predict individual feed intake: two Transfer Learning (TL) models based on Convolutional Neural Networks (CNNs), one CNN model trained on both feed types, and one Multilayer Perceptron and Convolutional Neural Network model trained on both feed types, along with categorical data. We also implemented a statistical method to compare these four models using a Linear Mixed Model and a Generalised Linear Mixed Model, showing that all models are significantly different. The TL models performed best and were trained on both feeds with TL methods. These models achieved Mean Absolute Errors (MAEs) of 0.12 and 0.13 kg per meal with RMSE of 0.18 and 0.17 kg per meal for the two different feeds, when tested on varied data collected manually in a cowshed. Testing the model with actual cows' meals data automatically collected by the system in the cowshed resulted in a MAE of 0.14 kg per meal and RMSE of 0.19 kg per meal. These results suggest the potential of measuring individual feed intake of dairy cows in a cowshed using RGBD cameras and Deep Learning models that can be applied and tuned to different types of feed.

Year 3. Biometrics methods, which currently identify humans, can potentially identify dairy cows and cattle. Given that animal movements cannot be easily controlled, identification accuracy and system robustness are challenging when deploying an animal biometrics recognition system on a real farm. Our proposed method performs multiple-cow face detection and face classification from videos. by adjusting recent state-of-the-art deep-learning methods. As part of this study, a true system was designed and installed at a height four meters above a feeding zone at the Volcani Institute's dairy farm. Two datasets were acquired and annotated, one for facial detection and the second for facial classification of 77 different cows. We achieved a mean average precision (mAP) (at Intersection over Union of 0.5) (IoU) of 97.8% using the YOLOv5 algorithm, and facial classification accuracy of 96.3% using a Vision-Transformer model with a unique loss-function borrowed from human facial recognition. Our combined system can process video frames with 10 different cows' faces, localize their faces, and correctly classify 25 their identities in less than 20 milliseconds per frame. Thus, up to 50 FPS video files can be processed with our system in real-time at a dairy farm. We developed a measurement system with producer convenience and low investment as key design criteria.

Keywords: Cow Individual feed intake; Precision livestock farming (PLF), Deep learning, Cow facial recognition, Vision-transformer, Biometric identification