RESEARCH ABSTRACT

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ANIMAL WELFARE

Title: Automated computer vision system for tracking individual pig activity and locomotion in nursery/finisher group housing **– NPB #18-149**

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Scientific Abstract:

Computer vision systems have the potential to provide automated, non-invasive monitoring of livestock to aid farmers in the identification of a host of behaviors and activities that could prove indicative for health and production metrics. However, the lack of public datasets with well-defined targets and evaluation metrics presents a significant challenge for researchers. Consequently, existing solutions often focus on achieving task-specific objectives using relatively small, private datasets. This work introduces a new dataset obtained from tracking n = 192 pigs from weaning to harvest (132 consecutive days). Video was recorded using Lorex security cameras over each pen with video captured at 5 frames per second at 2k resolution. Video data was exported via FTP to Intel 8-core i9 CPUs with NVIDIA 2080ti GPU 12 TB 7200 rpm Hard Drives. Video was processed utilizing MATLAB. The method for instance-level detection of multiple pigs in group-housed environments uses a single fully-convolutional neural network to detect the location and orientation of each animal, where both body part locations and pairwise associations are represented in the image space. Accompanying this method is a new dataset containing 2000 annotated images with 24,842 individually annotated pigs from 17 different locations. The proposed method achieves over 99% precision and over 96% recall when detecting pigs in environments previously seen by the network during training. To evaluate the robustness of the trained network, it is also tested on environments and lighting conditions unseen in the training set, where it achieves 91% precision and 67% recall. Furthermore, maintaining tracking of individual animals in a group setting is a exigent task for computer vision and animal science researchers. When the objective is months of uninterrupted tracking and the targeted animals lack discernible differences in their physical characteristics, this task introduces significant challenges. To address these challenges, a probabilistic tracking-by-detection method was employed. The tracking method uses, as input, visible keypoints of individual animals provided by a fully-convolutional detector. Individual animals are also equipped with ear tags that are used by a classification network to assign unique identification to instances. The fixed cardinality of the targets is leveraged to create a continuous set of tracks and the forward-backward algorithm is used to assign ear-tag identification probabilities to each detected instance. Tracking achieves real-time performance on consumer-grade hardware, in part because it does not rely on complex, costly, graph-based optimizations. A publicly available, human-annotated dataset is introduced to evaluate tracking performance. This dataset contains 15 half-hour long videos of pigs with various ages/sizes, facility environments, and activity levels. Results demonstrate that the proposed method achieves an average precision and recall greater than 95% across the entire dataset. Analysis of the error events reveals environmental conditions and social interactions that

are most likely to cause errors in real-world deployments. The datasets for detection and tracking are both publicly available for download at http://psrg.unl.edu/Projects/Details/12-Animal-Tracking. Individual pig activities were generated using the aforementioned tracking program for traits such as time spent laying (sternal and lateral), standing, eating, rotations, distance traveled, and velocity when in motion. Data were analyzed in SAS for associations with production traits such as average daily gain, final weight, back fat and loineye area. Correlation across time was also analyzed. For brevity, distance traveled was the main trait examined. Distance traveled was significantly associated ($p < 0.01$) with average daily gain, final weight, and back fat and trended towards significant for loineye area ($p = 0.11$). More distance traveled reduced averaged daily gain, final weight, and backfat. After the third week on test, weekly distance traveled was correlated with the following week's distance with correlations ranging from 0.75 to 0.92 with the exception of week 6 to week 7 when the pigs were moved and mixed in finisher pens. Individual pig data were analyzed on pigs removed prior to the scheduled end of the trial. For pigs that were removed for lameness, removed pigs tended to show clear patterns several days prior to treatment or removal by farm staff. Combined the program developed and data generated offers great promise in the use of computer vision to aid farmers in improving production and well-being of swine.