

Cattle monitoring with drones for weight estimation in confinement

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Abstract

Determining the optimal slaughter point for beef cattle is a critical challenge for maximizing production efficiency and profitability in the livestock sector. This study proposes an innovative approach for the automated monitoring of growth and fattening in Nelore cattle under feedlot conditions, using unmanned aerial vehicles (UAVs) and artificial intelligence techniques. Between July and October 2024, thirteen flight operations were conducted at the Campanário Farm feedlot (Laguna Carapã-MS), resulting in the collection of approximately 10,000 aerial images of 110 individually identified animals through hot-iron branding. The images were processed using semantic segmentation techniques to extract body measurements and estimate the weight of each individual. The system aims not only to accurately predict weight but also to detect anomalous behaviors and conditions that may impact zootechnical performance, such as bovine sodomy, weakness, and inadequate feed distribution. As an additional contribution, the *NelloreBeefCattleDataset*, containing approximately 10,000 annotated samples, was developed and made publicly available. Various deep learning models implemented in PyTorch and TensorFlow were evaluated. The expected outcomes include improved decision-making in feedlot management, reduced animal stress, and increased accuracy in determining the ideal slaughter time. The work is currently ongoing.

Keywords: cattle monitoring, UAV, artificial intelligence, semantic segmentation, weight estimation.

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1. Introduction

Beef cattle farming is one of the most important sectors of the Brazilian agricultural economy, playing a vital role in supplying the domestic market and exporting beef. However, determining the ideal slaughter point for animals remains a significant challenge, directly impacting production efficiency and the profitability of cattle farmers. Traditional weighing methods require intensive handling and can cause stress to the animals, negatively affecting their welfare and performance. Therefore, it is essential to develop technological approaches that enable automated and accurate monitoring of animal growth and fattening.

The use of drones to capture aerial images of cattle emerges as an innovative and efficient solution for estimating the weight of feedlot-finished animals. By applying deep learning techniques, it is possible to correlate the shape and body dimensions of the animals with their weight, enabling continuous and less invasive monitoring (Barbedo; Koenigkan et al., 2018). With this approach, the system can identify when each animal reaches its optimal slaughter weight, taking into account feed efficiency and economic viability.

In this context, from July 10 to October 27, 2024, thirteen drone flights were conducted at the Campanário Farm feedlot, located in the municipality of Laguna Carapã, Mato Grosso do Sul, Brazil, monitoring 110 Nelore cattle. For individual identification, each animal was hot-iron branded on the hip upon entering the feedlot. Weekly drone operations enabled aerial surveys and continuous tracking of animal growth throughout the confinement period. The integration of drones and artificial intelligence makes it possible to monitor individual growth trajectories, assess weight gain performance, and determine the optimal slaughter point to maximize financial returns.

This work aims to develop a cattle monitoring system using drones and artificial intelligence techniques implemented in platforms such as PyTorch and TensorFlow. The central proposal involves creating models to estimate animal weight based on semantic segmentation and body measurements extracted from aerial images. In addition to weight estimation, the study also explores other applications, such as the detection of anomalous bovine behaviors (e.g., sick animals, stress, mounting behavior, limping), which can directly affect performance and weight gain.

The methodology adopted in this study involves the systematic capture of high-resolution aerial images using drones, image processing via computer vision and

deep learning algorithms, and result validation by comparing estimated weights to ground-truth measurements obtained using conventional scales. In this way, the study aims to provide an innovative and feasible alternative for beef cattle monitoring, contributing to the modernization and optimization of the livestock sector.

The contributions of this work differ from existing studies in the literature in the following aspects:

- We created a dataset named NelloreBeefCattleDataset, composed of 10,000 annotated samples of Nelore cattle, which is made publicly available for academic purposes. The dataset can serve as a benchmark for weight estimation in Nelore cattle.
- We evaluated different deep learning models for animal weight estimation based on semantic segmentation and body measurements extracted from drone images.
- In addition to weight estimation, other research lines related to cattle monitoring were investigated. These applications were identified during the feedlot period and include: 1) detection of mounting behavior and limping animals; 2) analysis of feed distribution along the trough; 3) bovine feces analysis; 4) identification of animals lying down with signs of weakness or malnutrition; and 5) correlation between initial and final weights to determine the optimal weight range for calf purchasing.
- We demonstrate how the results generated by our model can be implemented in other feedlot operations to estimate the weight of Nelore cattle under confinement conditions.

2. Methods

Between July 10 and October 27, 2024, flights with an Unmanned Aerial Vehicle (UAV) were conducted over the feedlot at Campanário Farm, located in the municipality of Laguna Carapã, Mato Grosso do Sul, Brazil (Latitude: 22°47'8" S; Longitude: 55°3'57" W). The operations were carried out at a constant altitude of 10 meters using a Phantom 4 Advanced multicopter UAV equipped with a 20-megapixel Sony camera (5472 × 3648 pixels).

The feedlot houses approximately 14,600 animals, of which 110 Nelore cattle from pen F6 were selected for monitoring. Each animal was individually identified through hot-iron branding on the hip, numbered from 1 to 110 (Figure 1).



Figure 1. (A) Aerial view of the feedlot at Campanário Farm; (B) UAV in operation at an altitude of 10 meters; (C) Image acquired by the UAV at 10 meters altitude, displaying Nelore cattle; (D) Three cattle identified by hot-iron brands located on the hip; (E) Individually numbered cattle for identification.

Photo: Everton Castelão Tetila

Over a period of 112 days, thirteen flight operations were carried out on a weekly basis, resulting in the collection of approximately 10,000 aerial images. Each image could contain multiple occurrences of animals. The captured images were processed using semantic segmentation techniques, which classify each pixel in the image into specific categories, allowing for precise delineation of the objects of interest (Long et al., 2015). Each generated segment corresponds to an individually detected animal, associated with its identification number and estimated weight.

The integration of UAVs with artificial intelligence techniques enables the monitoring of individual animal growth, estimation of weight gain over time, and determination of the optimal slaughter point, with the aim of maximizing production efficiency and the economic return of the production system.

3. Results and Discussion

Although the study is still in progress, the expected results are promising. Based on previous studies and preliminary tests, we anticipate that the deep learning models applied to aerial images will achieve high accuracy in estimating the body weight of Nelore cattle. Semantic segmentation techniques are expected to allow precise delineation of each animal's body structure, enabling the extraction of body measurements that are highly correlated with actual weights.

The monitoring system is also expected to successfully identify and categorize behavioral patterns such as bovine sodomy, stress, and signs of illness, which may indicate animal health issues. Furthermore, image-based analysis of feed distribution along the troughs and fecal distribution patterns may contribute to assessing animal welfare and feed efficiency.

The public release of the *NelloreBeefCattleDataset*, containing approximately 10,000 annotated samples, is expected to support other research initiatives, fostering innovation in livestock monitoring through computer vision and artificial intelligence.

Ultimately, the integration of UAVs and AI models is expected to reduce the need for manual weighing, thereby minimizing animal stress and optimizing operational efficiency. These expected outcomes will contribute to better decision-making in feedlot management, including more accurate determination of the optimal slaughter point, improved feed allocation, and early detection of anomalies that may compromise animal performance.

4. Conclusion

This study introduces an innovative approach to cattle monitoring under feedlot conditions, combining UAV-based image acquisition with artificial intelligence to estimate weight and detect behavioral anomalies. Although the research is ongoing, the proposed methodology shows strong potential to transform traditional livestock management practices.

The expected outcomes include a reduction in animal stress due to non-invasive monitoring, increased precision in determining optimal slaughter timing, and improved data-driven decision-making by farm managers. Furthermore, the public release of the NelloreBeefCattleDataset represents a significant contribution to the scientific community, enabling the development and benchmarking of new models for cattle monitoring.

As the project progresses, the final analysis will validate the effectiveness of the proposed system, potentially paving the way for its large-scale adoption in commercial feedlot operations.

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