Automatic classification of Sow Claw Lesions in Confined Herds in Brazil

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Abstract

The present work seeks to address a recurring issue in swine production that, despite technological and scientific advances, remains frequently overlooked—largely due to producers' limited technical knowledge. This study proposes the development of an automated method for detecting and classifying swine hoof lesions, with the aim of enabling early identification and preventing consequences such as reduced herd longevity and reproductive disorders. Ultimately, the goal is to integrate the detection and classification model into an embedded system implemented as a mobile application, thereby making lesion monitoring and classification more practical, efficient, and accessible.

CCS Concepts

• **Computing methodologies → Neural networks**.

Keywords

Claw Lesions,Digital Image Analysis,YOLO,Machine Learning

1 Introduction

Locomotive impairment in breeding sows [1], caused by claw lesions, is a significant issue in modern pig farming and is considered one of the main factors leading to decreased reproductive and productive performance, as well as negatively affecting animal welfare [5]. A study conducted by [9] reported relevant data on the prevalence of this condition: approximately 2,660 sows from 30 distinct farms were evaluated, of which 99.1% presented at least one type of claw lesion. Among these cases, 51.2% were classified as mild, 38.9% as moderate, and 9.9

Although most cases correspond to mild lesions, they should not be overlooked, as they may contribute to the early stages of more severe pathological processes. The most frequent lesions observed in the study were: (1) sole overgrowth and erosion, (2) horizontal wall cracks, and (3) main toe overgrowth. The distribution and typology of the identified lesions were consistent with the findings of previous investigations, such as [3], reinforcing the relevance and persistence of this issue within the context of pig production.

It is evident that the problem described is indeed very common. The high proportion of sows presenting at least one type of lesion (99.1%) is, in fact, something consistently observed across studies ranging from early investigations to more recent research. One might assume that, given the prevalence of these numbers, hoof lesions are not particularly serious; however, they often trigger a series of consequences, creating a "snowball effect". Pain is the main aggravating factor. When swines experience pain, they tend to lie down for longer periods, which reduces physical activity. Consequently, their intake of water and feed decreases, substantially increasing the occurrence of urinary disorders that ultimately impair reproductive performance [4]. In other words, hoof lesions function as a precursor problem, and early detection is essential. The critical issue is that a herd of breeding sows with low reproductive performance and poor health results in economic losses for producers, since these animals only begin generating profit after three to four farrowings [8]. Moreover, the removal of animals from the herd, known as "culling", due to locomotor deficiencies is one of the main reasons for such practice [2, 14]. Thus, sows develop lesions, progress to locomotor impairment and related complications, and are ultimately removed from production, thereby reducing longevity and diminishing the profitability of the operation. In addition to these consequences, a herd with a high incidence of locomotor problems is also a strong indicator of substandard animal welfare conditions [2, 12].

Although the ideal scenario is to identify hoof lesions as early as possible, given all the potential consequences, they remain a problem that, despite significantly affecting the quality of life of swine herds, still lacks sufficient attention from producers [9, 2]. According to [9], the process of monitoring and evaluating hooves is a quick and reliable method for estimating the presence and potential progression of lesions, thereby guiding the necessary treatment decisions. Based on their study, it is recommended to perform an evaluation every five to six months, ensuring better decision-making and preventing the worsening of existing issues. However, like any form of visual classification, this process is still highly susceptible to differing interpretations regarding diagnosis.

1.1 Goals

The relevance of claw lesions to swine production underscores the need for reliable monitoring tools; therefore, this study aims to develop an automatic classification method capable of identifying the main types of claw lesions observed in pig farming and determining their respective levels of severity. By providing an accessible and applicable solution for routine use, the proposed model is expected to support strategies that promote swine longevity, encourage systematic lesion assessment, and strengthen best practices in herd management.

In order to achieve the main objective, the following specific objectives are established:

- Make a literature review about computer vision methods and deep learning applied in the detection and classification of lesions in production animals, with enfasis in swines;
- structure, organize, and curate a dataset of swine claw images that includes diverse lesion types and severity stages, ensuring the quality, representativeness, and suitability of the samples for training robust models.
- define and apply an image segmentation protocol, supported by expert annotation, to accurately delineate lesion regions and assign the corresponding severity levels;
- Develop an automatic detection model based on the YOLO architecture, focusing on reliable identification of pig claws under non-standardized imaging conditions;
- implement and validate an integrated claw classification and segmentation model, incorporating it into the previously established detection workflow to form a complete diagnostic pipeline.
- To evaluate the performance of the developed and trained models through adequate quantitative methods, such as precision, recall, F1-score and mean Average Precision (mAP), in order to assess their accuracy, robustness, and generalization capacity;
- Propose the deployment of the trained models on an embedded system or mobile application, enabling practical adoption of the methodology in commercial swine herds and supporting improved monitoring and management practices.

1.2 Justification

This research justifies, above all, by the limited attention that the presented theme still receives from most pig producers. On top of a vastly accessible computational tools and neural networks of high performance, it shows to be totally viable the development of such embedded system – for example, in the way of a mobile application – that promotes the adoption of a culture of evaluation, classification and constant monitoring of the evolution of claw lesions.

2 Theoretical framework

After considering the vast variety of available technologies for the development of such project, in special in what refers to classification algorithms, a comparative and systematic analysis will be conducted between different methods. However, the model decided to do the detections of the claws on non-standard images will be the YOLOv8 [13]. Originally introduced by [11], this neural network has received several updates through the years and can be considered a highlight when choosing a detector network, specially for not relying on a very high volume of data in order to obtain satisfactory results when training a model. Besides, it is highly fast and light, capable of performing detections in very reduced times in comparison to other concurrent networks.

The adopted metrics for evaluation of performance, both the detector and the classifier model, include precision, recall, F1-score and mAP (mean Average Precision). Such metrics allow for a comprehensive analysis of the model capability in identifying correctly positive and negative instances. Denotaded by TP the True Positives, TN the true negatives, FP the false positives and FN the false negatives.

The precision, given by the equation 1, evaluate how precise the model was in its execution, in other words, it measures how reliable it is with what it says to be true on the detections.

$$precision = \frac{VP}{VP + FP} \tag{1}$$

The recall, expressed by the equation 2, measures the capability of the model in identifying correctly all the positive cases. In other words, it evaluates if the model was capable of detecting all the truly segmented objects on the image during the training process.

$$recall = \frac{VP}{VP + FN} \tag{2}$$

The F1-Score, given by the equation 3, represents a metric of balance between precision and recall. In a summarized way, it evaluates both capability of the model in correctly detecting objects on the image and in avoiding the omission of real instances, in other words, objects that should have been identified.

$$F1 = 2 \times \frac{Precision \times Recall}{Precision + Recall} \tag{3}$$

Finally, the mAP metric, given by the equation 4, evaluates both precision on the location and classification of the objects, considering all classes and different confidence thresholds.

$$mAP = \frac{1}{n} \sum_{i=1}^{N} AP_i \tag{4}$$

3 Methodology

For the purpose of developing a scope of work, this project will focus on the automatic detection of three main lesions identified in [10], as well as the classification of its respective levels of severity, defined in four stages: 0 (healthy claw), 1 (mild), 2 (moderate) and 3 (severe). As shown in the example dataset (Figure 2), the lesions represent mild and severe cases of the three main lesions found in the literature, cells 1A and 1B refers to the sole overgrowth and erosion, mild and severe, cells 2A and 2B refers to the horizontal wall crack, again, mild and severe cases, and cells 3A and 3B refers to the main toe overgrowth with a mild and severe case.

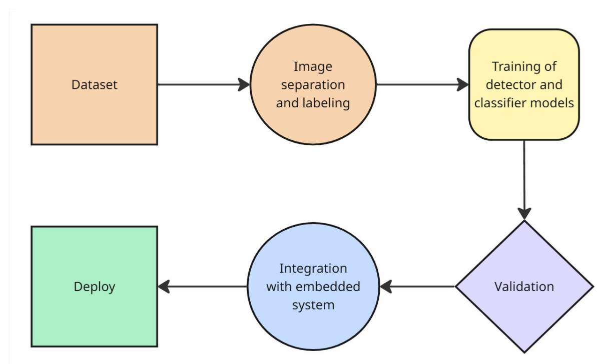

Figure 1: Flow of training and validation of the models.

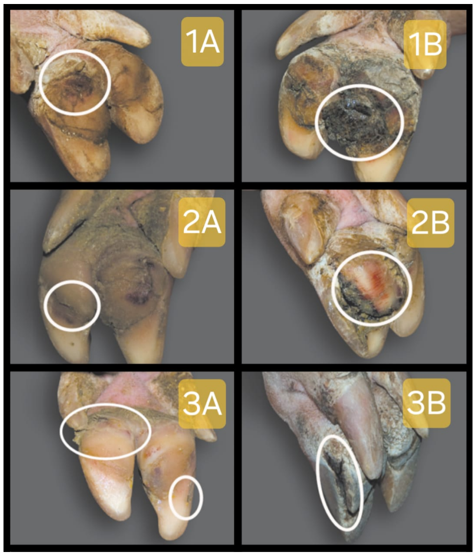

Figure 2: Example of the *dataset* to be used on the training of the detector and classifier model. Source: Adaptaded from [6].

The proposed system will be developed based on a methodological flow composed by the steps of training, validation and application of the model, as seen in (Figure 1), covering the processes of detection, segmentation and classification. Considering that the available images show significant variations in framing, illumination and positioning of the animal – potentially containing one or more claws in one scene (Figure 2) – it will be essential, in a first moment, to identify correctly the correspondent regions of the claws. Only after this step of detection it will be possible to apply in an effective way the segmentation and classification algorithms responsible for the analysis of the lesions.

The data used for training the model will be sourced from the image dataset initially presented in [7], which has been continuously expanded up to the time of this work's development. The dataset will consist of images collected under different experimental conditions and will undergo a manual labeling process carried out by a specialist in pathology or swine management. This step is essential to ensure the consistency and reliability of the annotations used in the supervised learning process.

The development of the system will include the training and validation of a detector model specialized in the identification of pig claws, based on the YOLOv8 [13] architecture. This choice is motivated by the balance between computational performance and precision, which makes this architecture specially adequate for applications in mobile embedded systems, favoring the practical use of the system on production environments.

4 Results and expected contributions

It is expected that a reliable model will be developed, specialized in the main hoof lesions found in swine production and capable of distinguishing both the different lesion types and their respective severity levels. Once a specialist model is obtained, with minimal divergence in its assessments, meaning that its lesion classifications align closely with the judgments of different veterinary experts, the next step is to deploy it in an embedded system implemented as a mobile application.

Through this system, the study seeks to promote a consistent culture of swine lesion assessment, an aspect that the literature highlights as lacking adequate attention, and, by increasing accessibility, to contribute to enhanced sow longevity and reproductive performance. By facilitating early and systematic lesion identification, the project is expected to reduce the number of sows that require euthanasia, enabling them to remain productive for longer periods, both reproductively and economically.

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