

# Fully automatic scoring of pleurisy in slaughtered pigs: first trial under field condition

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## Abstract

This study presents the first trial under field conditions of a fully automated, artificial intelligence-based technology for scoring pleurisy in slaughtered pigs (ADAL: Automatic Detection of Abattoir Lesions). The aim was to evaluate the feasibility of using an automated system for scoring pleurisy in slaughtered pigs under field conditions, using an AI-based system that employs deep learning algorithms and image processing techniques to analyse images of pig lungs captured during post-mortem examination. The experimental setup demonstrated the potential of AI-based systems to improve disease detection in pig populations and reduce the risk of errors associated with traditional manual scoring methods. A total of 19,029 images were analysed, and pleurisy was detected in 10.24% of the half-carcasses. The majority of the pigs (89.76%) did not exhibit any signs of pleurisy. Among the pigs that exhibited pleurisy, the most common score was 2 (4.7%), followed by scores of 3 (3.84%) and 1 (1.7%). Norway's low prevalence of pleurisy compared to other countries is attributed to its strict import regulations and the absence of several important respiratory pathogens. The results suggest that AI-based technologies could provide a fast and cheap tool to systematically record lesions in slaughtered pigs, supplying useful data to all stakeholders in the pig industry. The development and application of AI-based technologies could deeply modify the professional life of veterinarians, without affecting their key role in implementing the best disease control strategies. The study represents the first step in developing a fully automatic method for real-time and systematic analysis of animal health, production, and welfare parameters at the slaughterhouse. Future studies are expected to refine and improve the accuracy and efficiency of AI-based technologies in detecting and scoring pig lesions, providing invaluable support to farmers and veterinarians in maintaining the health and productivity of pig herds.

## Keywords

pleurisy, scoring, computer vision

## Introduction

Porcine respiratory disease complex (PRDC) is a significant health issue that causes severe economic losses in the global pig industry. The severity and outcomes of PRDC are influenced by various factors, including the immune status of the animals, environmental factors such as the level of ammonia and dust, and managerial factors such as overcrowding and biosecurity strategies. These factors can disrupt the balance between herd immunity and pathogens, leading to disease outbreaks (Opriessnig *et al.* 2011).

PRDC is caused by a range of viruses and bacteria, often occurring as concurrent infections. One of the major causative agents of PRDC is *Actinobacillus pleuropneumoniae* (App), which is responsible for porcine pleuropneumonia (Gottschalk and Taylor 2019). The impact of App in pig herds can be properly estimated at slaughterhouses, which are recognized as a key checkpoint for assessing the health status of farm animals, as well as the effectiveness of strategies implemented to prevent or treat disease conditions (Fraile *et al.* 2010). Several scoring methods have been developed to estimate the economic impact of diseases in slaughtered pigs. The "Slaughtered Pleurisy Evaluation System" (SPES) grid is widely considered the most informative method for pleurisy lesions' classification. It involves the use of an evaluation grid with values between 0 and 4, depending on the presence, extent, and position of pleural lesions. The SPES grid can indeed be effectively used directly to score pleurisy observed in the slaughter line (Merialdi *et al.* 2012). Recently, an alternative scoring method has been developed called "Pleurisy Evaluation on Parietal Pleura" (PEPP), which can be used to score pleurisy on the chest wall and demonstrates a strong correlation with SPES.

Notably, the PEPP method can be performed on digital images and has been used to train a convolutional neural network (CNN) to score pleurisy on such images, taken by veterinarians along the slaughter chain (Di Provvio *et al.* 2019; Trachtman *et al.* 2020).

The present study aims to report data collected in a Norwegian slaughterhouse using a fully automatic, artificial intelligence (AI)-based technology, namely ADAL (Automatic Detection of Abattoir Lesions) developed by Farm4trade (Atessa, Italy).

### **Materials and methods**

The study was conducted between September and December 2022 in a medium-sized slaughterhouse in Norway, using a camera robot prototype (Farm4trade Srl, Atessa, Italy). The prototype consisted of a 6-axis collaborative robot equipped with two 4K cameras and sensors capable of capturing images along the slaughtering chain. The robot could support payloads of up to 5 kg and was equipped with a collision detection and trajectory reproduction system, making it ideal for use in scenarios involving human-robot collaboration. The prototype was positioned after the removal of viscera and showering operation, and it took pictures of half carcasses with the aim to acquire the best pictures of the inner surface of all half-carcasses, including the chest wall.

As the half-carcasses progressed along the slaughter line, they were not rotated to gain the best positioning for the camera. Therefore, several pictures were taken and screened from one of the two half-carcasses using an ad hoc developed algorithm. The algorithm was designed to automatically identify and extract the image of the pig chest wall with the best quality for pleurisy scoring by PEPP method, and to eliminate images that were either too rotated or out of focus or had poor lighting conditions (Table 1).

The selected image for each pig was temporarily stored on a local server, uploaded to a cloud server, and analysed by the trained CNN. To optimise the CNN's performance, it was fine-tuned on a small set of approximately 300 images collected under similar slaughterhouse conditions. The fine-tuning process involved adjusting the CNN's parameters and training it on the new data set to improve its accuracy in identifying pleurisy on chest walls. The fine-tuned CNNs of ADAL were then used to automatically detect and score pleurisy as described in Trachtman *et al.* (2020).

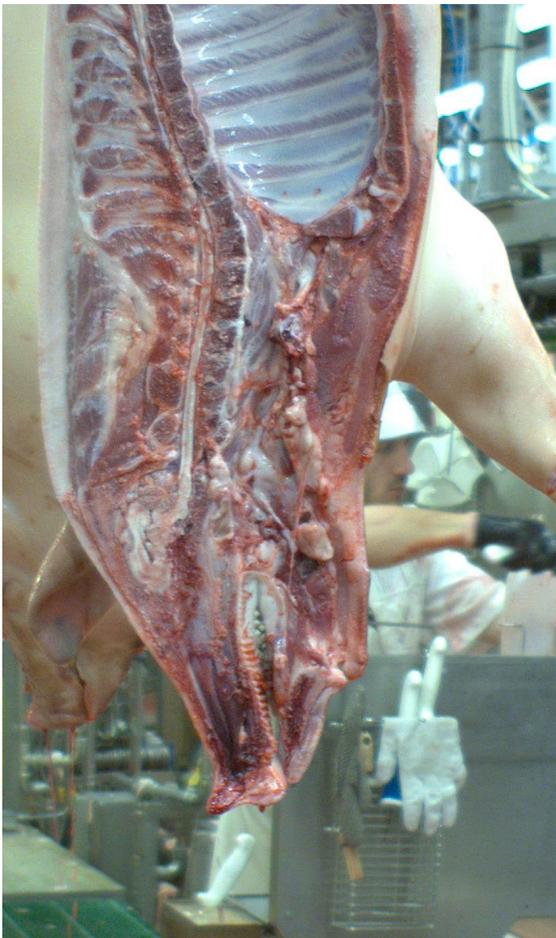


Table 1: examples of pictures unsuitable for analysis that have been discarded

## Results

A total of 37,798 pictures of half-carasses were taken during the study, out of which 19,029 pictures were considered suitable for analysis by CNN. Of the 19,029 images analysed, pleurisy was detected by ADAL in 1948 half-carasses (10.24%). The distribution of pleurisy scores is presented in Table 2.

Pleurisy Score	Number of Pigs	Percentage
0	17,081	89.76%
1	323	1.7%
2	894	4.7%
3	731	3.84%

Table 2: distribution of pleurisy scores in slaughtered pigs produced by the ADAL system

The majority of the pigs (89.76%) did not exhibit any pleurisy and were assigned a score of 0. Among the pigs that exhibited pleurisy, the most common score was 2 (4.7%), followed by scores of 3 (3.84%) and 1 (1.7%) (see Table 3).

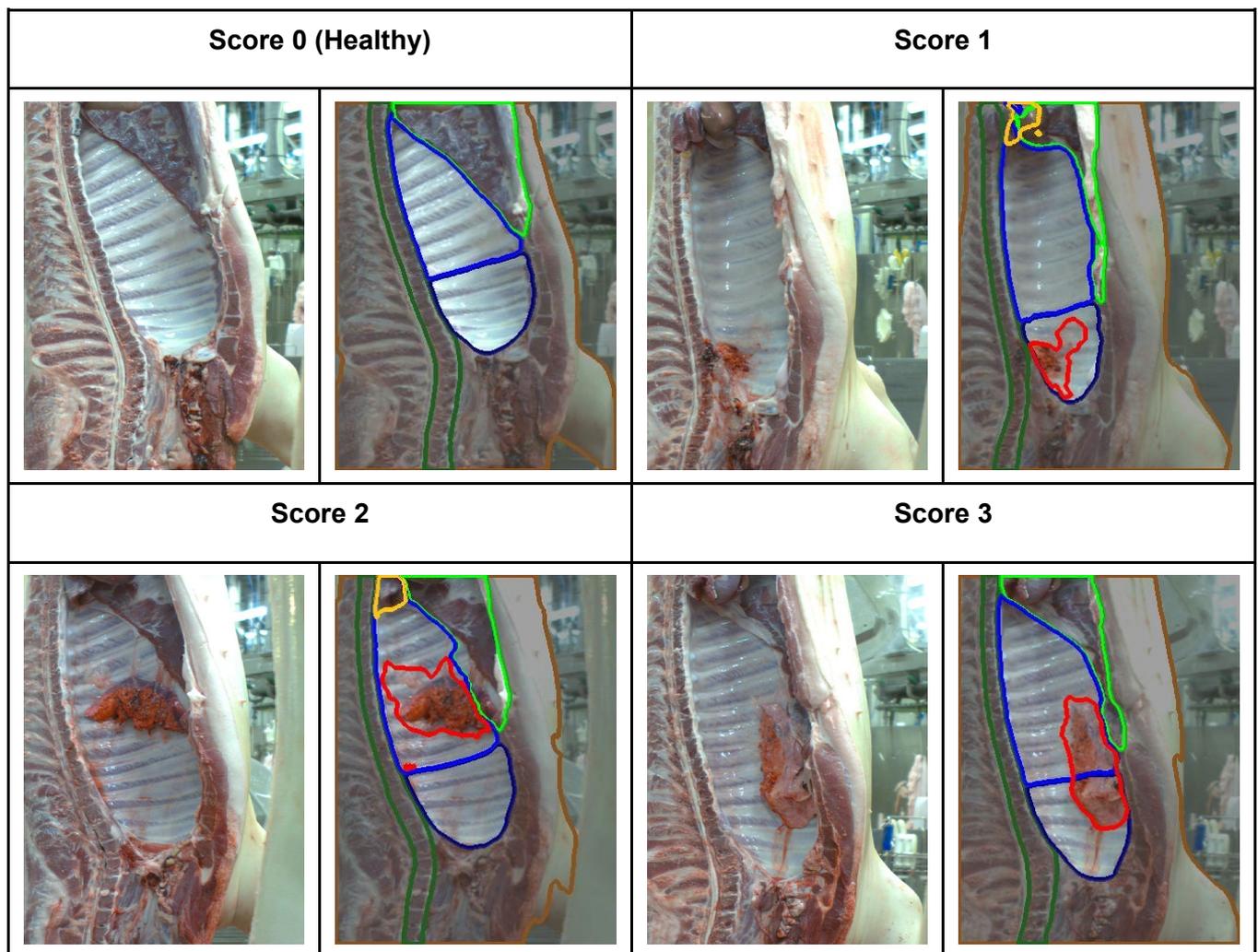


Table 3: examples of pictures acquired and scores assigned by ADAL according to Trachtman *et al.* (2020)

## Conclusion

This preliminary investigation under field conditions demonstrates the potential of AI-based technologies in livestock production. AI can efficiently record vast amounts of data at slaughterhouses, improving the health status and profitability of pig farming. Artificial intelligence-based methods are very topical and promising, poised to revolutionise most human activities, including those in the field of biomedical sciences. Deep learning approaches, unlike previous technologies, do not require manual or instrumental measurements for classifications or scores (Esteva *et al.* 2017). AI-based technologies offer a fast, cost-effective way to systematically record lesions in slaughtered pigs, providing valuable data for stakeholders and encouraging improved herd management as suggested by scientific literature.

In our opinion, the development and application of AI-based technologies will significantly transform the professional life of veterinarians while preserving their crucial role in accurately interpreting data and implementing the most effective disease control strategies. The extensive data generated through AI-based technologies will indeed be readily accessible, enhancing epidemiological investigations at regional, national, or international levels and fostering progress towards evidence-based medicine.

The prevalence of pleurisy observed in our study seems considerably lower compared to findings from other countries (Maes *et al.* 2023). However, it aligns with the data on pleurisy prevalence detected in Norway through meat inspections and recorded in the USR ("Utvidet sykdomsregistrering" or "Extended disease registration"), which ranges between 6% and 7% for the years 2016-2020 (*personal communication*). In this respect, we highlight that the health status of Norwegian herds is very high, as Norway is free from Aujeszky's disease virus, PRRSV, SIV (apart from influenza A [H1N1]pdm09), and *Mycoplasma hyopneumoniae* (M.hyo), which play a key role in the aetiology of PRDC (Cohen *et al.* 2020).

Our work represents the first step and a significant milestone in developing a fully automatic method for real-time and systematic analysis of animal health, production, and welfare parameters at the slaughterhouse. To the best of our knowledge, this is the first work addressing organ lesions scoring in pigs in an automated, data-driven fashion, providing a rapid, reliable and consistent instrument for detecting pleurisy in pigs and reducing the risk of errors. We anticipate that future studies will further refine and improve the accuracy and efficiency of AI-based technologies in detecting and scoring pig lesions, providing invaluable support to farmers and veterinarians in maintaining the health and productivity of pig herds.

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