USE OF ARTIFICIAL INTELLIGENCE TO EVALUATE STANDARD OPERATING PROCEDURE (SOP) FOR BOVINE CARCASSES IN BRAZIL

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I. INTRODUCTION

In slaughterhouses, Standard Operating Procedures (SOPs) ensure consistent application of safe practices during processing of beef carcasses, in addition to having a direct impact on profitability of beef carcasses, ensuring a high standard of quality in final products through standardization of cuts, effective removal of unwanted parts and ensuring that carcasses are in ideal conditions for consumption. Among SOPs adopted by slaughterhouses that can influence economy, removal of tallow from pelvis and removal of paw bone are procedures whose inadequate execution directly affects final weight of carcass and, consequently, profitability of slaughterhouse. An effective solution to monitor and ensure correct execution of SOPs is implementation of use of computer vision with artificial intelligence (AI). By implementing AI systems to monitor SOPs, meatpackers can ensure not only product safety and quality, but also operational efficiency and resource maximization, enabling a proactive approach to identifying potential issues. This enables immediate and ongoing corrections to optimize performance and minimize waste, thus promoting better practices and more consistent results in beef processing industry. The objective of this research is to use AI to monitor in real time procedures carried out in slaughterhouses, identifying potential inappropriate practices, resulting in increased industrial efficiency.

II. MATERIALS AND METHODS

The autonomous system for capturing images of beef carcasses installed in slaughterhouse used high-resolution cameras and lenses and built a dataset containing 1500 images. Images were captured automatically after animal's slaughter procedure at exact moment half-carcasses were weighed on scales on overhead rail. Two SOPs were evaluated: pelvic tallow and paw bone. The captured images were annotated by trained professionals, in two classes: class 0 – adequate SOP and class 1 – inappropriate SOP. After annotated dataset, a model trained with YOLOv8 architecture [1] was used, responsible for simultaneous detection and classification, detecting 100% of region of pelvic tallow and paw bone in bovine carcass. For classification of SOPs, it was carried out in a separate model using Resnet101 architecture [2], well consolidated in literature. A training set (80% of captured images) was used to train AI models (MOD AI) and a test set (20% of captured images) was used to evaluate performance of MOD AI. Based on evaluation results, performance of model trained using reserved test set was evaluated using metrics such as precision, recall, F1-score and confusion matrix to understand model's classification ability (accuracy). And, subsequently, final tests were carried out using a separate validation data set to verify robustness and generalization of model, and thus implement it in a real test environment, a beef carcass slaughterhouse production line, to validate performance and practical feasibility of proposed solution. Performance and feasibility were based on 1000 images captured and classified by MOD AI.

III. RESULTS AND DISCUSSION

Based on performance metrics for evaluating AI models, best model obtained presented 80% and 92% for pelvic tallow and paw bone, respectively, as shown in Table 1 and Figures 1 and 2.

Table 1. Performance evaluation metrics of trained model for classes of beef carcass SOPs.

Fat Coverage	Precision	Recall	F1-Score	Support
		Pelvic Tallow		
Class 0	0.80	0.80	0.80	138
Class 1	0.80	0.80	0.80	134
		Paw Bone		
Class 0	0.96	0.93	0.94	258
Class 1	0.95	0.92	0.94	220

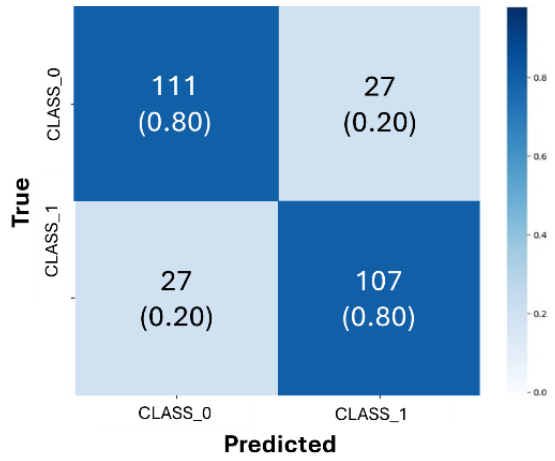

Figure 1. Confusion Matrix Normalized - Pelvic Tallow

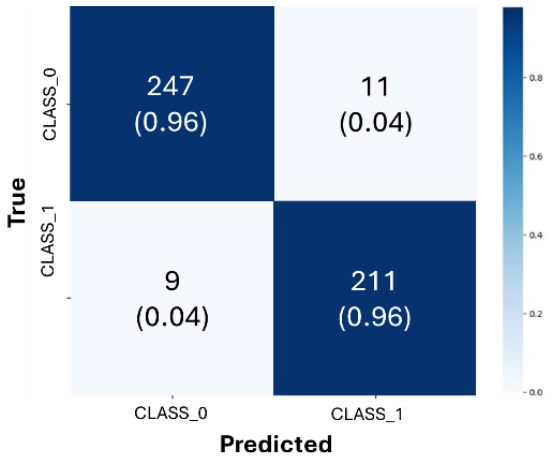

Figure 2. Confusion Matrix Normalized - Paw Bone

Application of Paw Bone verification algorithms, on 1000 images of bovine carcasses, showed 74% of Inadequate SOP. When we consider addition of 210 g (real weighed values) of tarsal bones present in 74% of carcasses, this amounts to an additional disbursement of up to US$ 14,918.40 per month for 18 thousand animals slaughtered. Application of Pelvic Tallow verification algorithms, in 1000 images of carcasses, showed 22% of inadequate SOP, that is, with inadequate removal of tallow from basin. It is estimated that each inadequate SOP adds 150 g (real weighed values) of tallow present in 22% of carcasses, resulting in an additional disbursement of up to US$ 3,168.00 per month for 18 thousand animals slaughtered.

IV. CONCLUSION

With integration of artificial intelligence solutions, slaughterhouses can further improve their processes, achieving higher levels of efficiency and precision in execution of SOPs. It should be noted that algorithmic models still need to be validated in an operational environment, requiring continuous development efforts in real conditions.

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