USE OF ARTIFICIAL INTELLIGENCE TO EVALUATE BEEF CARCASS FAT COVERAGE IN BRAZIL

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I. INTRODUCTION

In meat processing industry's slaughter line, evaluation of the fat coverage on carcasses is carried out by trained technicians, using human vision. The results of this assessment are communicated to industry, indicating proportion of carcasses in different classification standards according to market requirements, being crucial to guide their direction. Slaughterhouses throughout Brazil work to ensure quality of carcasses, especially beef fat coverage, directing products to more than 150 importing countries and to broad domestic market. Classification of carcasses in Brazil continues to be subjective, depending on human evaluation, which, combined with the inherent subjectivity, can lead to partial evaluations that affect redirection of products on market. According to Vadivambal and Jayas [1], estimated accuracy of a subjective visual model ranges from 40% to 50%. Recently, Daniel et al. [2] demonstrated an accuracy of 92.86% using artificial intelligence (AI) in classifying beef carcasses, with a margin of error of 7.14% considered acceptable. The adoption of an autonomous AI-based system for automated classification of beef carcasses can ensure impartiality, accuracy and reliability in data, essential for optimizing targeting of carcasses in accordance with commercial product standards. This will allow generation of fundamental data for decision-making aimed at improving and promoting market standards both nationally and internationally. The objective of this research is to use AI to classify in real time fat coverage of beef carcasses carried out in slaughterhouses, identifying potential in quality and inferring increased industrial efficiency.

II. MATERIALS AND METHODS

The autonomous image capture system installed in slaughterhouse to identify beef carcasses used high-resolution cameras and lenses and built a dataset of 2000 images. Images were captured automatically after animal's slaughter procedure at the exact moment half-carcasses were weighed on scales on overhead rail. These images were recorded, by trained professionals, in three classes according to market product: class 1 – no fat coverage, class 2 – uneven fat coverage, class 3 – standard fat coverage Afterwards, obtained dataset was divided into a training set (1500 images) to train AI models (MOD AI) by ordinal classification [3], and a test set (500 images) 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, after MOD AI was validated, it was implemented 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 9,085 images captured and classified by a slaughterhouse technician (on-site classification) compared to classification by AI model.

III. RESULTS AND DISCUSSION

Based on AI model evaluation performance metrics, best model obtained presented 88% accuracy, as shown in Table 1 and Figure 1.

Table 1. Model performance evaluation metrics trained for beef carcass fat coverage classes.

Fat Coverage	Precision	Recall	F1-Score	Support
Class 1	0.92	0.98	0.95	136
Class 2	0.73	0.79	0.76	121
Class 3	0.94	0.86	0.90	243

Table 2. Assessment of fat coverage of beef carcasses when AI model is adopted.

Fat Coverage	*In loco*	MOD AI	If adopted AI	
			Elevate	Decline
Class 1	762 (8.4%)	673 (7.4%)	↑423	---
Class 2	2803 (30.9%)	2418 (26.6%)	↑1349	↓230
Class 3	5520 (60.8%)	5994 (66%)	---	↓1024
Total	9085 (100%)	9085 (100%)	↑1772 (19.5%)	↓1254 (13.8%)

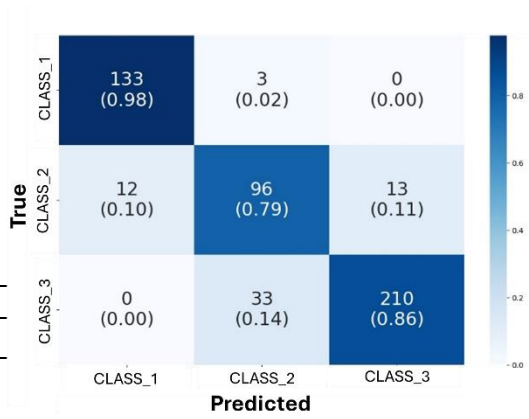

Figure 1. Confusion Matrix Normalized

Application of MOD AI algorithms on 9,085 images of carcasses collected in slaughterhouse showed alignment with local Classifier in 66.7%, and, if applied, in real decision-making in industrial flow (Table 2). However, AI algorithms would classify 3026 carcasses (33.3% of total) differently as follows: AI would consider 1772 (19.5%) carcasses as being of a higher fat coverage class than that assigned by local Classifier, demonstrating a real effective gain in recognition of carcasses with best coverage by a homogeneous and impartial computational system. AI would reposition 1254 (13.8%) carcasses as having a lower fat coverage class than that assigned by local Classifier, which is also a real gain for slaughterhouse's operations, as it more accurately and transparently recognizes conditions of carcasses that are entering industry.

IV. CONCLUSION

Use of AI in slaughterhouse's industrial flow not only provides a homogeneous and impartial evaluation system but can also result in a significant improvement in accuracy of carcass classification. This translates into an optimization of production process, better recognition of quality products and, potentially, greater economic efficiency. It is noteworthy that algorithmic models still need to be validated in an operational environment, requiring continuous development efforts and significant improvements in image capture and synchronization software in real conditions.

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