PORK MARBLING SCORES: COMPUTER VISION SYSTEM AGAINST TRADITIONAL METHOD

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Abstract – Marbling pork plays an important role in sensory quality of food. The traditional method of marbling assessment in pork requires panelists for grading based on a photographic standard, a subjective, costly, tedious and slow task. Computational techniques, as computer vision approaches, are often applied as an alternative to avoid the disadvantages of traditional method. The aim of this paper was to compare the performance of traditional method based on panelists against Contrast-limited Adaptive Histogram Equalization, a Computer Vision technique. The comparison is based on marbling standard score of National Pork Producers Council. The different experts attributed the same grades in only 56.25% of the samples. The computer vision system has assigned grades similar to one of the experts in 93.75%. Thus, traditional assessment by panelists can be replace by the computer vision system that is automated, fast, accurate and avoids the demerits of the traditional practice.

Key Words – image analysis, meat, NPPC.

I. INTRODUCTION

Historically, the assessment of marbling pork is done subjectively by trained panelists using photographic classification standards. An example of conventional visual assessment is to compare the pork sample with model provided by the National Pork Production Council (NPPC). NPPC model presents seven marbling scores: from 1 (devoid) to 6 and 10 (abundant) [1]. For panelist, the marbling visual association of score is influenced by visual interpretation subjectivity. This is in due to poor repeatability and the strong influence of the environment on evaluators, besides being a lazy evaluation, costly and tedious [2] [3] [4].

Thus, we propose an evaluation methods in a more objective way to determine the marbling level in pork meat using digital imaging and computing, specifically a Computer Vision System (CVS).

CVS performs the segmentation of intramuscular fat, that is, detecting the fat area avoiding brightness of specular reflection and other noises that may be present in the image of sample [5] [6]. It is known that pork features a lower color contrast between fat and muscle when compared to other types of meat, requiring more sophisticated methods of segmentation [2].

One of the key steps of CVS is the enhancement of images that usually occurs before the segmentation process. The contrast enhancement of an image is one of the main techniques of image processing [7]. Targeting a contrast enhancement approach, i.e, Contrast Limited Adaptive Histogram Equalization (CLAHE) may represent an adequate solution to the low contrast problem on pork images. The CLAHE has already been successfully used to assist the segmentation process in other CV work, as can be seen in [8] [9] [10].

Therefore, the aim of this paper was to compare the marbling score assigned by traditional method and the proposed CVS. The NPPC quality standard was used by different panelists and CVS to score the samples.

II. MATERIALS AND METHODS

This study was conducted in two experiments. The first considered the assessment by panelists and how it was scored following the NPPC model. The second experiment was about assignment of fat percent in sample and its correlation with NPPC standard by CVS. Finally, there was a comparison of the two techniques.

Samples

We used a dataset composed by 400 digital images of different samples of *longissimus dorsi* muscle

(between 12-13 pork ribs). The images was taken using a digital single-lens reflex camera and a tripod that supported the device at 37cm above the sample.
The camera was configured with the automatic settings. The image sensor comprised 16.2 megapixels and there was a high quality lens which was optimally engineered to gather more light. Three different panelists used the standard NPPC to score the marbling pork images.

Computer Vision System

The CVS was developed using MATLAB software (version 2014b). The tests were performed on a computer with Mac OS X v10.10, 8 gigabytes of RAM and an Intel Core i5 processor (third generation).
After the reading of the image, the red and blue channels were changed to apply a process of segmentation by thresholding in Hue (Hue channel using the HSV color space). The threshold value found by the Otsu method [11] is widely used in literature [12]. Our next step was small area remotion (less than 0.1% of the picture), thus resulting only from the Region of Interest (ROI) .
Max entropy thresholding was applied on ROI in order to remove the fat layer cap, after the holes were filled to prevent marbling regions from remotion.
CLAHE was applied at this part of process to increase the contrast between muscle and fat, followed by an erode process to remove the problems caused on the image edge. A new thresholding by Max entropy was applied targeting the marbling. Finally, small area remotion (less than 0.01% of the picture) was performed to avoid ROI from brightness and the marbling area was detected.
The proposed CVS was performed using each scored example image of NPPC standard to find an interval of fat percentage associated to each levels (Table 1). In this way, the CVS is capable to grade any pork meat image.

Table 1. Fat percentage segmented by the CVS based on NPPC

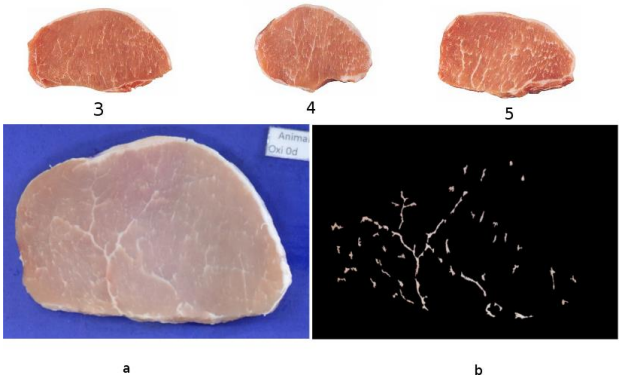
	Min. %	Max. %
Score 1	0	0.4
Score 2	0.4	1.6
Score 3	1.6	3.8
Score 4	3.8	8
Score 5	8	12
Score 6	12	16
Score 10	16	30

III. RESULTS AND DISCUSSION

Experiment 1

The scores attributed by the panelists did not exceed the level 5, showing the reality of marbled meat in Brazil.
The result of panelists scores in an unanimity way was about 56.25%, only 225 samples.
The panelists attributed grades completely different in 3.5%, 14 samples. The Figure 1 shows an example with scores assigned to 3, 4 and 5. The left image (a) shows the evaluated sample scored by panelists and the right image (b) shown a processed image with 2.99% of fat region. On the top of Figure 1 are marbling levels of NPPC associated by panelists. This result reflects the subjectivity of the evaluation and dependence of the constant training of panelists.
Time is another disadvantage of traditional method. The panelists took an average of 11s to assign a score for each image, not including pauses.

Figure 1. Example sample with assigning different scores.



Experiment 2

The CV solution had lower scores than or equal to 5 as the panelists.

Our CVS obtained a percentage in the mean of panelists about 93.75%, i.e; the software has assigned scores equal at least one of the panelists.
Considering time, CV solution spent less than 2.5s per image, without breaks.

Comparison

Table 2 shown the results of experiments, it was observed that if CVS was used added to panelists group, the overall variance would be increased, from 0.05% to 0.09%.
However, the score standard deviation of the CVS (considering all levels) was lower in comparison to each humans, revealing greater uniformity.
Another relevant fact was a trend of minor levels be less uniformly attributed by panelists. According to levels marbling decrease, our CVS shows a more stable and less susceptible to error.
Time spent by the CVS is four times lower than traditional method without considering the necessary breaks of panelists.
Software performance becomes even greater since the technique can be applied to an image composed by multiple samples.
Therefore, it is considered that the boredom of features and slowness were mitigated. Regarding the cost, after built, a CV solution requires no costs. If considered the assessment by digital image by the panelist, photographic equipment would be used in both approaches.

Table 2. Comparison between of method classification the marbling pork by panelists and CVS

Item	Panelists	CVS
Time (s)	11	2,5
Std. between grades	0.28%	0.13%
Variance between evaluators	0.05%	0.09%

IV. CONCLUSION

Thus, the proposed CVS was shown a viable alternative compared to the traditional assessment of pork marbling, replacing a human expert and mitigating the problems panelists evaluation.
Computer Vision transforms the marbling pork score in an objective and fast assessment, once the machine evaluates multiple images without pauses; and lower cost in comparison to the panelists who need training. This alternative can be applied to a production line in a slaughterhouse.

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