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IDENTIFICATION OF THE MARBLE MEAT STANDARD THROUGH THE NEURAL NETWORK FOR QUALITY GRADING

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Abstract. With the growth of the beef industry, the speed of operations in slaughterhouse lines has dramatically increased. The wide variations in beef cattle genetics complicate the classification of beef cuts, products, and quality data documentation. To address these challenges, intelligent automation is considered a viable solution for a fast, objective, consistent and accurate beef grading of quality. The beef marbling is one of the most important indicator of beef quality grading by measuring the abundance of intramuscular fat. In recent years, an artificial neural network was used to remain the primary learning methods in the field of computer vision for food classification evaluation. In this paper, an automatic grading of beef marbling combining image processing and Neural Network was developed to generate a database reducing the human factor in the classification.

Keywords: Marbling, Neural Network, Image Processing, Quality, Artificial Intelligence

1. Introduction

Quality is a key factor modern food industry because the high-quality of the product is the basis for success in today highly competitive market. In the food industry, the quality evaluation still heavily depends on manual inspection, which is tedious, laborious, and costly, and is easily influenced by physiological factors, inducing subjective and inconsistent evaluation results (Du and Sun, 2006). Also, the wide variations in beef cattle genetics complicate the classification of beef cuts, products, and quality data documentation. This can eventually result in mislabelling (RMIT, 2018).

Among many quality attributes, marbling, which is defined as the amount and spatial distribution of visible white flecks of fat present within the lean in the longissimus dorsi (LD) muscle, is one of the most important traits determining the quality of meat. Wherefore, marbling is often considered as an important characteristic that directly affects consumers consumption decisions. In most developed countries, the degree of marbling is the main assessment index for grading the quality of meat and there is often a very high correlation between marbling score and price (Cheng *et al.*, 2015).

So far, the visual appraisal is still the most preferred method used by the meat industry for the evaluation of marbling degree. Besides, as another conventional method, chemical analysis has also been widely used as a standard method for the determination of marbling degree, but these 2 methods have disadvantages by being subjective and time-consuming. Unfortunately, up to now, no comprehensive review is available on the methods and techniques for marbling analysis (Cheng *et al.*, 2015).

The application potential of computer vision to the food industry has long been recognized as a rapid, economical, consistent and even more accurate and objective inspection tool, computer vision systems have been used increasingly in the foods industry for quality evaluation purposes. Initially inspired by biological systems, ANN (Artificial Neural Network) approaches combine the complexity of some of the machine learning of imitating human intelligence, which is characterized by their self-learning capability. If the quality evaluation is achieved automatically, production speed and efficiency can be improved in addition to the increased evaluation accuracy, with an accompanying reduction in production costs (Du and Sun, 2006).

In this work was proposed a method to estimate the score of marbling, meat, and fat. For this an image processing was developed to determine a recognition area and using this data to input in an Artificial Neural Network, creating a pattern and determine a classification of this image, optimizing this process.

2. Artificial Neural Network (ANN)

The artificial intelligent, presented in Figure 1, is a method can be used for such purposes since their primary target is to distinguish objects or groups or populations. Artificial neural networks (ANN) are a well-known mathematical tool widely used and tested lately for the problems in meat production and technology. Its advantages are in the ability to handle nonlinear data, highly correlated variables identification of problems or classification (Prevolnik *et al.*, 2011).
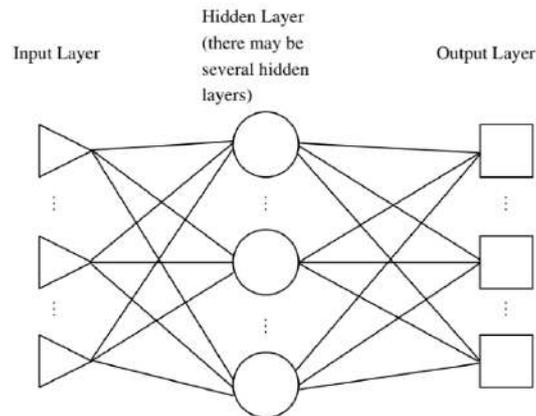

Figure 1. The general topology structure of artificial neural network

The sensory texture of food should be determined by sensory testing as no instrument or combination of instruments can fully replace the human senses. However, for instrumental measurements to replace sensory attributes, they must provide accurate predictions. This is achieved by first building a prediction model, based on the calibration of the instrumental measurements with sensory measurements of the same objects. Accordingly, one of the most promising alternatives to overcome this limitation is the application of artificial neural networks (ANN) since they are computational techniques well adapted to non-linear data (Carvalho *et al.*, 2013).

This technique has the main function of finds patterns between received information, called input data, and the results that this information provides in a system called Target data. Once the pattern is found a neural network can be used to reproduce entirely that system, dismissing others calculations when its all trained.

A neural network has a certain number of simple processing elements called neurons (or perceptrons). Each one is connected to other neurons using direct communication links. Each link has an associated weight. The weights collectively represent information being used by the network to solve a problem. A neural network is characterized by its architecture, training, and activation function. Architecture describes the pattern of connections between neurons. Training indicates the methods used to determine the weights associated with each link (Kim *et al.*, 1997).

If the number of hidden neurons is too low the learning process can be obstructed, if the number of hidden neurons is too big the network can be overtrained. When developing BP-ANN (Back-Propagation Artificial Neural Network), besides the mentioned number of neurons in a hidden layer, the following parameters of the network should be optimized: learning rate (0.1-0.9), momentum term (0.0-1.0), and several epochs (starting with sample size, optimized on the test-set error). When ANN is trained to a satisfactory level, the weighted links among the units are saved and later used as an analytical tool to predict results for a new set of input data (Prevolnik *et al.*, 2011).

2.1 Classification

The existing methods for meat quality (palatability) grading heavily rely on the subjective visual appraisal of certain characteristics. While visual appraisal has been serving the industry for decades, it has some major drawbacks. Although the graders are professionally trained, inconsistencies and variations are intrinsic of subjective evaluations. This has seriously limited the ability of the meat industry to provide consumers with products of consistent quality. Computer vision has been recognized as the most promising approach to the objective assessment of meat quality from fresh-meat characteristics. Beef quality assessment by image processing started with the work by Chen, McDonald, and Crouse in 1989 to quantify the marbling area percentage in six standard USDA marbling photographs (Tan, 2004).

Computer vision, presented in Figure 2, is a science about how to make computers "see" by installing eyes (camera) and brain (algorithm) to it, and it can provide superior spatial information of detected samples. When employing computer vision technology to automatically evaluate marbling scores, the image processing process usually involves the operations of segmentation of the LD muscle from the steak image, segmentation of marbling from lean LD muscle, and extraction of marbling features (Cheng *et al.*, 2015).
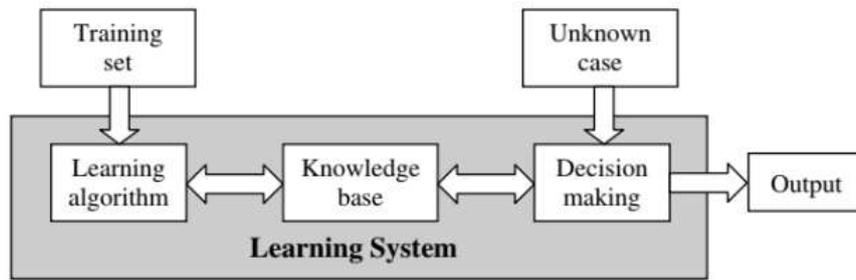
Figure 2. The general configuration of machine learning system

Among these operations, segmentation of the LD muscle from the steak image is necessary because graders assign marbling grades mainly based on visual appraisal of the LD muscle, and therefore it is the primary step in developing a successful marbling evaluation system by computer vision, which can be realized by thresholding, region growth, and morphological operations(Cheng *et al.*, 2015).

Some Computer Vision System (CVS) need to deal with nonlinearities between the image features and the marbling score of interest, making use of sophisticated modeling techniques from artificial intelligence. Thus, to implement a robust CVS able to cope with more complex scenarios, it is recommended to apply machine learning algorithms. Machine Learning (ML) is an effective tool for exploratory data analysis and is widely employed for various applications, including Computer Vision (da Costa Barbona *et al.*, 2017).

3. Results and discussions

For simplicity and lack of time in the present paper, we chose to perform a simpler calculation of meat vs. fat for illustration only, in which the percentage of external fat was calculated. internal meat (musculus longissimus).

As we only need the meat area in the image without any other factor that can change this value, the bottom removal was performed to enable the calculation of meat and fat percentages, a process that was performed in the software using a function to determine the characteristic of pixels, with this function, can create, add vertices, adjust the size and position of interactive polygons on the image. With this function, a position and characteristic for background and select object are defined and created fa layer for removal and another position to preserve the image.
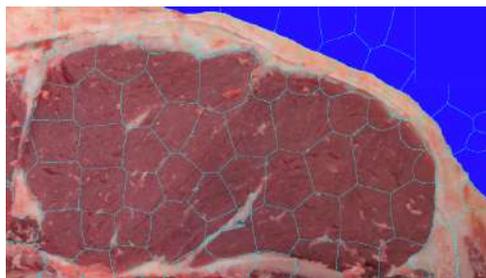

Figure 3. Representation of function with region called superpixel

In Figure 3 we use the superpixel function (simple iterative clustering algorithm (SLIC)) to group pixels into regions with similar values by segmenting the image into In small regions, using this function for image processing helps to reduce the complexity of this operation. For each image, there is a corresponding value of superpixel (number of regions in which the image will be segmented) called h1 and h2.

The Figure 4 represents the total area of meat and fat that we will use as 100% in the calculation of percentage.

The Figure 5, we can observe the segmentation of meat and fat (the representation of the meat in question is from Musculus Longissimus (kebab)). The corresponding photos (figure 4 and 5) were taken from inside the fridge, so the lighting used was the property itself, artificial light, the first images were made on a metal table where it reflects a lot of light and the color tone varies too much for purposes academics put the background in a single shade to make removal easier, because for current processing using the superpixel function and segmenting the image we need to have the same color tone in certain areas so the function can do the removal properly. In the future we plan to create a framework for standardized shooting of pre-set images with the lowest possible background, everything is in development, but we hope to get good results.

The Figure 5, we can observe the segmentation of meat and fat (the representation of the meat in question is from

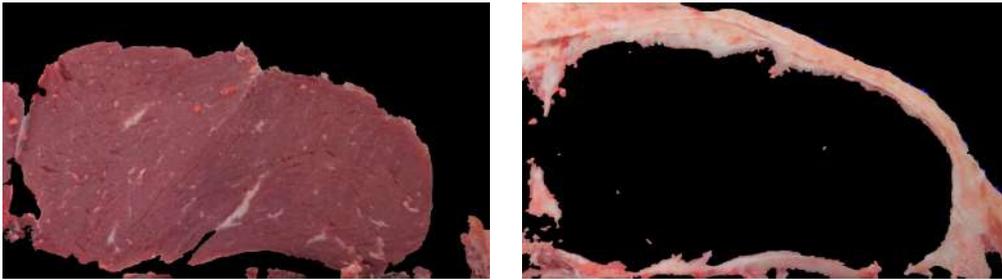Figure 4. Representation of Beef with no background

Figure 5. Representation of layer of the meat (a) and layer of the fat (b)

Musculus Longissimus (kebab)). The corresponding photos (figure 4 and 5) were taken without control, using the ambience lighting. This was done because the first images was obtained in production line. A adjust in images was done, excluinding the reference metal, used for tradicional classification method of the meat. The metal table where it reflects a lot of light and the color tone varies too much for purposes development of the tool for a classification automated, the background in a single shade make removal easier, because for current processing using the developed function and segmenting the image we need to have the same color tone in certain areas so the function can do the removal properly. In the future a new function to plan to create a framework for standardized shooting of pre-set images with the lowest possible background, everything is in development, based in get good results. In Figure 2, can see the flow diagram of the neural network, where the input is the processed image, the neural network system used for learning machine and the % of fat or meat as output post processing. For a Figure 4 the function developed realized a measure the total area of figure in pixels, where the Area Total (A_t) = 4.3380x10^6 pixel square, for Figure 5 (a) the layer for the Musculus Longissimus presents the Area (A_{ML}) = 3.157827$10^6$ pixel square for Figure 5 (b) the layer for Fat the Area (A_{Fat}) = 1.3059$10^6$ pixel square. With data obtained, can be defined a estimated percentage of meat and fat for Beef used for development as 72.8 % of Meat and 27.2 % of Fat.
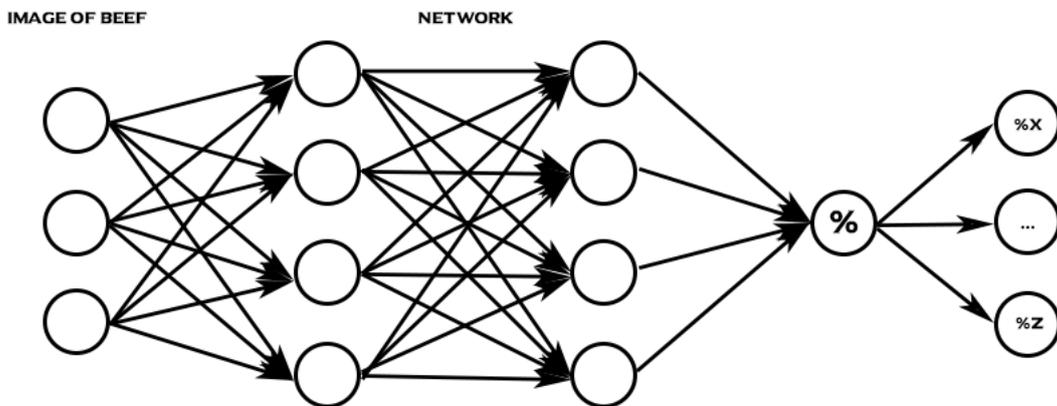

Figure 6. Application neural network

Observing Figure 6 the padronization for classification of meat is based on the percentage of Fat in the Meat. For each

percentage, $X\% \ldots Z\%$, the industry can define the classification basead in applied model of market current. With this information and the parameter defined as percentage of Fat in the Meat, for each cut, the Neural Network can realize a classification of the cut without human interference, objective of the function proposed.

4. Conclusion

Quality is a key factor for everything, because with such a market full of offers, the one who has the best product stands out and this is what we aim to achieve by setting parameters such as percentage of meat (Musculus Longissimus), external and internal fat (marbling) defined for the classification of meat.

In the meat industry, the standard used today is subjective and error-prone as it is based on visual assessment using tables that indicate what each meat is (lean, medium or fat) from appearance, and not the actual amount of meat vs. fat. Although employees are trained for the proper work, there are still many inconsistencies in the ratings obtained.

With computer vision at our side algorithms work like brains that have neurons capable of thinking and making decisions and cameras that act as eyes for these algorithms, from this technology it is possible to develop qualified and qualified prototypes to accurately and objectively classify procedures that are made so inaccurately today.

The artificial neural network (ANN) serves to be the brain of the system because, with pre-established parameters, we can teach it to recognize what meat and fat are autonomously to automate the whole meat qualification industry.

5. References

Carvalho, N.B., Minim, V.P.R., de Cassia dos Santos Navarro Silv a, R., Lucia, S.M.D. and Minim, L.A., 2013. "Artificial neural networks (ann): prediction of sensory measurements from instrumental data". *Food Science e Technology*, Vol. 33, pp. 722–729.

Cheng, W., Jun-HuCheng, Da-WenSun and HongbinPu, 2015. "Marbling analysis for evaluating meat quality: Methods and techniques". *Comprehensive Reviews in Food Science and Food Safety*, Vol. 14.

da Costa Barbona, A.P.A., Jr.b, S.B., Camposb, G.F.C., Jr.b, J.L.S., Peresa, L.M., Mastelinib, S.M., Andreoa, N., Ulricic, A. and Bridia, A.M., 2017. "Development of a flexible computer vision system for marbling classification". *Computers and Electronics in Agriculture*, Vol. 142, pp. 536–544.

Du, C.J. and Sun, D.W., 2006. "Learning techniques used in computer vision for food quality evaluation: a review". *Journal of food engineering*, Vol. 72, No. 1, pp. 39–55.

Kim, N.D., Amin, V.R., Wilson, D.E. and Rouse, G.H., 1997. "Neural network application for classifying beef intramuscular fat percentage". *Animal Science Research Reports*, Vol. Beef Research Report.

Prevolnik, M., Skorjanc, D., Candek-Potokar, M. and Novic, M., 2011. "Application of artificial neural networks in meat production and technology". *IntechOpen*, Vol. Industrial and Control Engineering Applications.

RMIT, U., 2018. "Intelligent solutions for boxed beef trim export enhancement". *AMPC*, Vol. 2017-1006.

Tan, J., 2004. "Meat quality evaluation by computer vision". *Journal of food engineering*, Vol. 61, pp. 27–35.

6. RESPONSIBILITY NOTICE

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