# DIRECTIONAL MORPHOLOGICAL OPERATORS TO DETECT FAT STREAKS IN IBERIAN HAM

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## Abstract

Iberian ham presents superior sensorial quality than other ones. Currently, chemical procedures are being used to determine fat level of the ham, but they can not give any information about its distribution. Some research made on Iberian hams from pigs with different feeding reveal similar fat level, but pigs fed on acorns and grass reached better qualifications in a sensorial analysis of the samples carried out by a trainer tester set. So, ham marbling, i.e. number, position, shape and size of intramuscular fat streaks in ham must influence its sensorial characteristics. In this work, digital image processing techniques based on mathematical morphology are proposed to achieve automated detection of fat streaks in commercial ham slices. A statistical study evaluating performance of the proposed methods is provided.

**Keywords**: Iberian ham, marbling, digital image processing, mathematical morphology.

## 1. INTRODUCTION

It is widely recognised that, from the point of view of the consumer, dry-cured hams coming from Iberian race pigs present superior sensorial quality than other ones. This fact is basically due to their higher intramuscular fat level and its distribution in the ham [1].

Currently, chemical procedures are being used to determine fat level of Iberian ham, but they can not give any information about its distribution [1,2]. Some researchers studied a set of dry-cured Iberian hams belonging to different feedings. Their chemical analysis revealed similar fat levels, but pigs fed on acorns and grass reached better qualifications in a sensorial analysis of the samples carried out by a trainer tester set [2]. So, ham marbling, i. e. number, position, shape and size of intramuscular fat streaks in ham, must influence its sensorial characteristics. Thus, intramuscular fat level percentage contained in the largest streaks is directly associated with ham marbling.

Our attempts are to investigate objective factors to classify Iberian ham from the viewpoint of sensorial quality. In this paper, a new digital image processing technique to achieve automated detection of fat streaks in commercial ham samples is proposed. We have developed a method based on directional morphological operators at different scales and orientations, which can be used to detect linear structures. A statistical study based on fat streak classification is also provided, and the results are compared with those found using a method based on the combination of non-directional morphological operators [3] and other simple thresholding techniques.

## 2. DATA

Four commercial ham slices, three coming from Iberian race and one from another race have been digitized with a general purpose scanner HP ScanJet 4C/T at a spatial resolution of 100 pixels per inch and grey-level resolution of 8 bits (256 grey levels). The area of the samples ranges from 88559 pixels to 210483 pixels, i.e., 47 $cm^2$ to 73 $cm^2$. All intramuscular fat streaks have been annotated by an expert in food technology. The total number of fat streaks annotated per image ranges from 29 to 89 (224 in the four images) and their areas range from 10 to 4264 pixels (1.58 $mm^2$ to 40 $mm^2$).

## 3. METHODS

We propose a new method to detect fat streaks using directional morphological operators at different scales and orientations (4 equidistant directions in our experiment). The operating principle of these operators is illustrated in figure 1, where $d$ represents the operator dimensions in pixels, $w$, its active region width and $\varphi$, its orientation. A directional operator improves line-signal to background noise ratio by taking the minimum grey level of the pixels lying on its locally oriented active region. Pixels are assumed to be square.

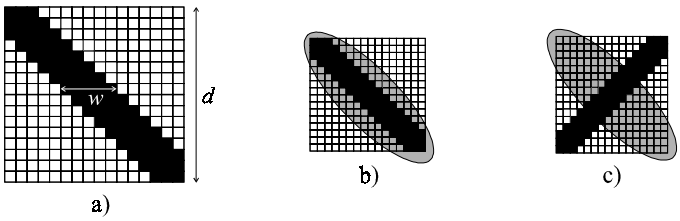


**Figure 1**. a) Directional morphological operator. b) Operator produces high response when operator and feature occur in the same direction. c) Operator produces low response when operator and feature occur in different directions.

A scaled series of morphological openings with directional morphological operators is applied to the original image. The width *w* of the operator is initially tuned to the maximum structure width to be detected, and is progressively decreased until 2 pixels, which is the minimum fat streak width considered. The resulting images, each containing information about linear structures in direction $\varphi_i$ and scale $d_i$, are composed by taking the maximum grey-level intensity of the correspondent pixels.

# 4. RESULTS

To evaluate detection performance, a statistical study based on FROC (Free Response Operating Characteristics) curves is provided [4]. Detection can be achieved by thresholding the resulting images. Different values of the threshold will result in different compromises between true and false positive values. Ten equidistant thresholds falling into the images dynamic range have been considered.

We consider a true positive when annotated and detected streak areas are at least 50% overlapped. With respect to false positives detection, the following criteria are assumed: 1) regions falling into 5 pixels distance around an annotated streak are considered as part of that streak, 2) regions smaller than the minimum annotated streak are ignored and 3) regions closer than 4 pixels one each other are merged.

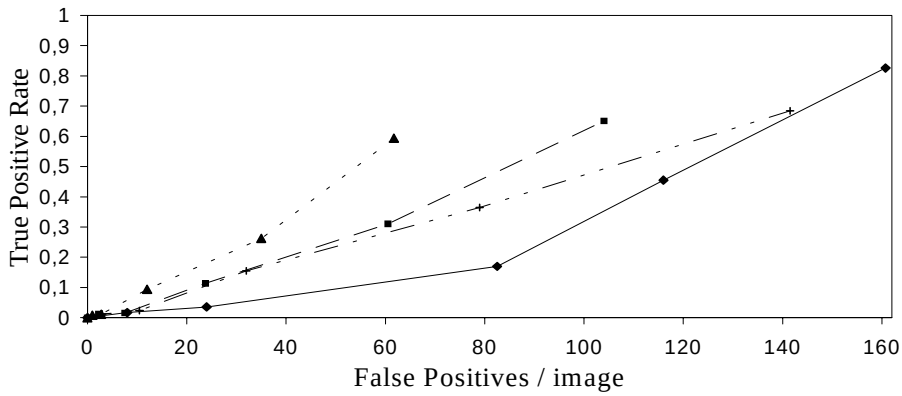


**Figure 2**. Comparison of fat streak detection performance for: unprocessed original images (◆), original images processed by a median filter with 3x3 mask size (+), original images processed by non-directional morphological operators (■), and original images processed by directional morphological operators (▲).

# 5. CONCLUSIONS AND FUTURE WORK

A novel method to detect intramuscular fat streaks in Iberian ham slices, based on directional mathematical morphology, has been proposed. A statistical study shows much better performance than other methods.

Future research will be focused in the following fields: test the methods with a larger database, increase the number of directions considered in the proposed method, develop other linear detection techniques and decrease false positives by applying region connectivity methodologies.

# 6. REFERENCES

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