

Prediction of Loin Muscle Area with the Autofom

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Summary and Implications

An active contour algorithm for prediction of loin eye area (LEA) in the transectional Autofom images has been developed and implemented. The results of 75 carcasses measured at Hatfield Quality Meats indicate a standard error below 1 square inch by combining the algorithm with the current 127 Autofom features. Future studies of more carcasses, optimization of the algorithm, and better energy functions are expected to improve the results. With a speed optimization of the algorithm, there is potential for using the Autofom for on-line sorting of loins based upon loin muscle area.

Introduction

The objective of the experiment is to predict the loin eye area (LEA) with the Autofom. The Autofom is an on-line ultrasound scanner consisting of 16 ultrasound transducers positioned in a U-shaped frame. The positions (3,200) are measured along the back of the carcass and extensive image analysis is performed in a Unix workstation. One hundred and twenty-seven features are output and used in a multivariate calibration to predict the grading information (e.g., primal cuts) (1).

Material and Methods

Experimental conditions. A test was performed at Hatfield Quality Meats in January 1997. Seventy-five randomly selected carcasses were measured with the Autofom over a 3 day period. The LEA was measured approximately 24 hours postmortem with a plastic grid at the 3rd from the last rib (approximately the 10 or 11-rib interface) on both sides of the carcass and averaged.

Image analysis. The fat and meat thickness profiles are well described in the 127 features currently extracted from the longitudinal images. Therefore, it was chosen to work on the trans-sectional images in the current project. An active contour algorithm (known as "snakes" in image processing terminology (2) was developed as a supplement for the 127 features.

Ten consecutive scans from each transducer in the loin section are averaged to form a two-dimensional trans-

sectional image. The image is rescaled by linear interpolation to improve the resolution between the transducers. A noise reduction is performed on the images with a Gaussian filter. Based upon a center point in the loin, a morphological boundary detection is performed in a star shape. Hereby, circularly spread points on the border of the loin are detected. An iterative update of the points is performed by minimizing an energy function depending on the shape of the "circle" and the gradient (edge) in the image and external constraints (e.g., no sharp edges). From the detected points, 10 shape features are extracted (area, perimeter, length, width, aspect ratio, minimum depth, maximum depth, area corrected to square millimeters, perimeter corrected to millimeters, and intensity count). The algorithm currently takes approximately 4 seconds per carcass, so there is a potential for on-line use with further optimization.

Results and Discussion

Table 1 shows the statistical information of the LEA reference measurements. Figure 1 shows four examples of the trans-sectional images with the detected points overlaid on the images. The reference value and the predicted LEA values are noted for each image. Ultrasound data were available for 73 of the 75 carcasses. The 10 features detected with the active contour algorithm were combined with the 127 Autofom features and used in a multivariate partial least squares calibration (3). The correlations and prediction errors results of the predicted and the measured LEA measures are given in Table 2. Inclusion of the 10 new features result in an increase in the prediction correlation from 0.68 to 0.75 and a decrease in the prediction error to 0.75 inch². The correlation plot is shown in Figure 2. It is obvious that the algorithm fails on a few occasions, especially due to a wrong initialization of the contour. Inspection of the images, however, also reveals some problems with the reference data. Especially on four occasions, where the LEAs were measured shortly after another on one of the days, there seems to be a mismatch between the ultrasound and the reference data. The top left image in Figure 1 is one of the examples of this occurrence. Removal of these four measurements increases the correlation to 0.79 for the 127 Autofom features, and to 0.82 for the predictions, including the new active contour features (Figure 3). The tendency seems to be that inclusion of the new contour features makes the prediction more stable to outliers.

References

1. Broendum, J., M. Egebo, and H. Busk. 1997. On-line pork carcass grading using the Autofom ultrasound system. *J. Animal Sci. J. Anim. Sci.* 76 1859-1868.

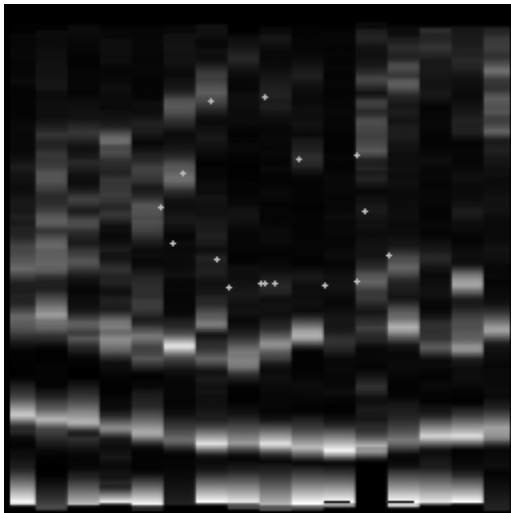
2. Kass, M., D. Terzopoulos, and A. Witkin, 1988. Snakes: contour models. p. 321-331. *Int. J. Comp. Vision* 1:321-331.

3. Martens H. and T. Naes. 1991. *Multivariate calibration*, 2nd edition. Wiley, ISBN 0-471-90979-3.

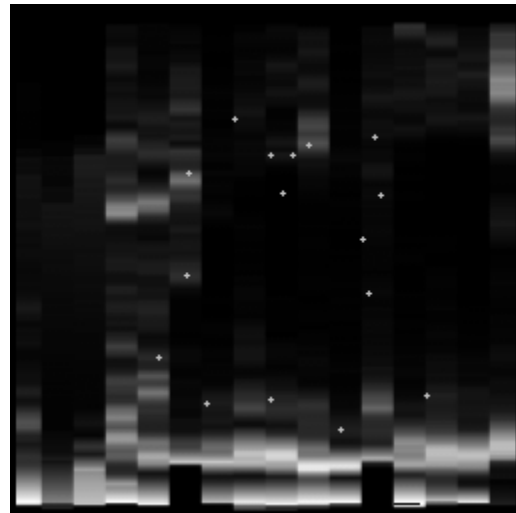
Table 1. Statistical information about the LEA (values in inch²).

Mean	sd	Min	Max
8.10	1.38	4.50	12.04

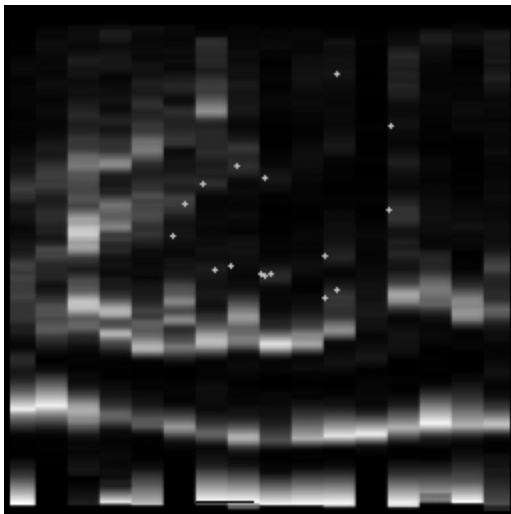
Figure 1. Trans-sectional Autofom images. The horizontal direction show the 16 transducers interpolated to 256 pixels. The vertical direction show the depth of the carcass. The overlaid dots are the points detected with the contour algorithm.



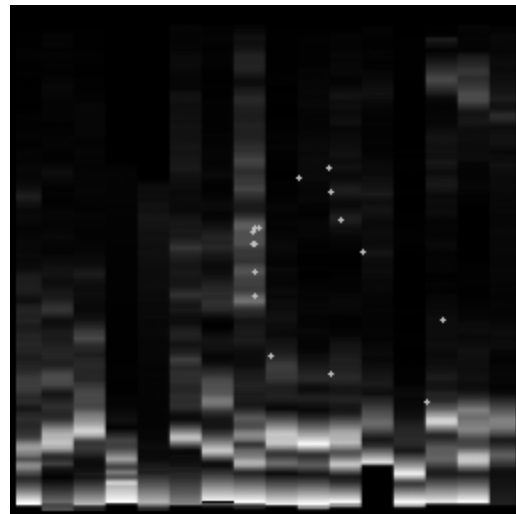
Measured LEA: 4.50 inch². Predicted LEA: 6.89 inch²



Measured LEA: 12.04 inch². Predicted LEA: 10.58 inch²



Measured LEA: 6.05 inch². Predicted LEA: 5.74 inch²



Measured LEA: 8.45 inch². Predicted LEA: 7.75 inch²

Table 2. Results of the multivariate prediction of LEA. Both the results from using the current 127 Autofom parameters and the results from including the new active contour parameters are cited.

Features Used	Correlation of Predictions	Standard Error of Predictions	No. Principal Components	Outliers Removed
Autofom 127	0.68	1.01	3	0
Autofom 127 + Active Contour	0.75	0.94	5	0
Autofom 127	0.79	0.81	3	4
Autofom 127 + Active Contour	0.82	0.76	5	4

Figure 2. Prediction plot of the 127 Autofom features and the active contour features. No outliers removed.

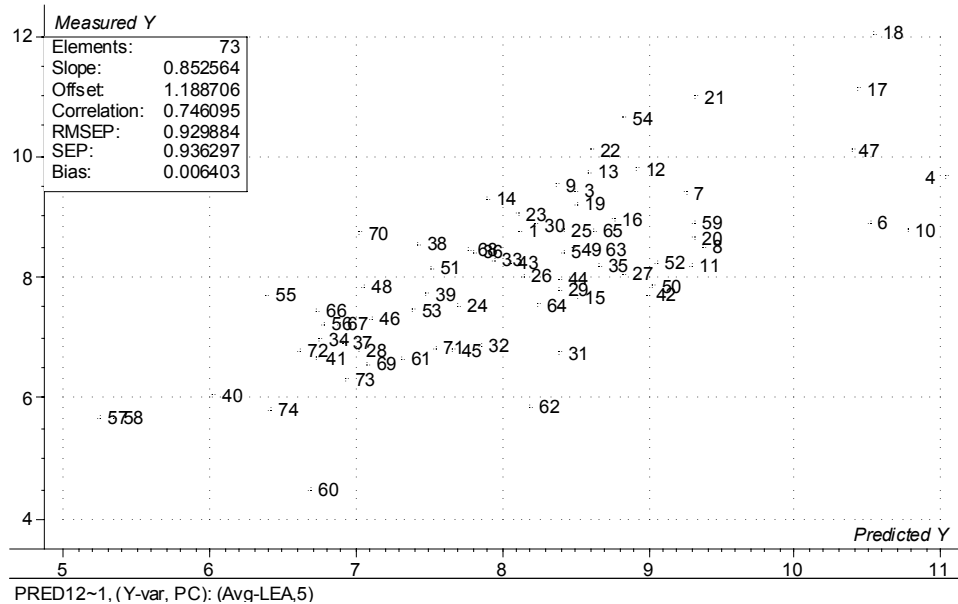


Figure 3. Prediction plot of the 127 Autofom features and the active contour features. Four outliers removed.

