Objective Meat Colour Measurement

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INTRODUCTION

Meat and fat colour are important in the objective assessment of meat quality, particularly in the marketplace. Meat colour is also being investiga as an indicator of tenderness and is used as an indicator of quality in international market quality standards. However, the measurement of colo is highly dependent upon characteristics of illumination, meat cut surface and observer. Furthermore, any objective measure of meat colour nee to be calibrated and reconciled with the subjective perception of the consumer. It must also be compared with other objective colour standards establish levels of repeatability and accuracy.

We have developed a system capable of measuring meat colour under controlled illumination and viewing conditions. The system uses a 3-chip CC colour video camera, diffuse illumination using standard halogen bulbs, and a colour framegrabber installed in a personal computer. The system ha demonstrated very good repeatability and accuracy. This paper presents results of using this system to measure and classify beef colour.

METHODOLOGY

The colour measurement system comprises a JVC KY-F30 colour video camera, Mosaic 24 bit colour framegrabber, PC, four tungsten-filament lig bulbs approximating the CIE standard illuminant A, and a hemispherical diffuser for even scene illumination. The system was developed with th aim of transforming RGB values of pixels as measured by the camera into the CIE $L^*a^*b^*$ colour space. The procedure, explained with more deta in Ref. [1], consists of gamma correction (linearisation of measured RGB values), dynamic range correction (taking into account change illumination and iris setting) and transformation to CIE XYZ tri-stimulus values. The coefficients of the transformation matrix were obtained b minimising the colour difference between the measured and actual values of a set of colour standards in units of CIELAB colour difference (197 This procedure gave repeatable and accurate results when applied to the data gathered over more than a year in time.

The development of the colour classification system had three major steps: acquiring images of the meat colour standard, development of a neur network for pixel colour classification and its implementation for meat colour classification of the test meat cut images. As it can be seen from Figu 1, our colour measurement system is able to differentiate between the various colour levels in the meat colour standard, and therefore a classification algorithm based on these $L^*a^*b^*$ values is possible.

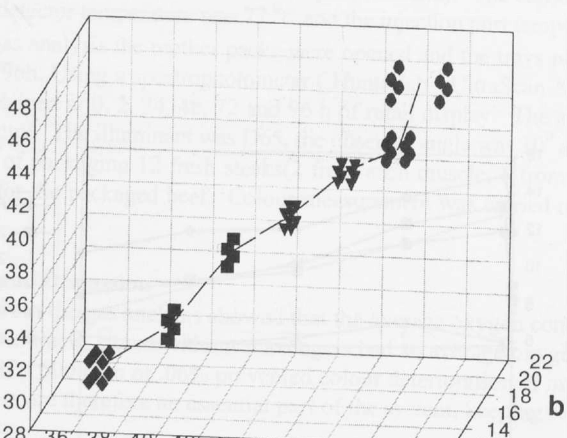

Figure 1:
CIELAB (L*a*b*) colour regions for the meat colour standards of a foreign controlling authority (mean plus or minus 3 standard deviations) as measured by our system. The mean value for each colour standard lies along the broken line.

The neural network employed in pixel colour classification wa built using Radial Basis Functions. It is particularly suitable for thi type of applications as in the first stage of network design th procedure involves unsupervised clustering of the input data. Th neural network was trained and tested using the colour da measured by our system. The overall classification rate of th training set was 0.98 and of the test set 0.95.

A typical meat cut classification procedure proceeds as follows:

- Acquire image of a meat cut;
- Define region of interest (ROI). Usually, the RO encompassed only the meat cut to speed up the classificatio process;
- Perform colour classification of pixels in the ROI discriminate "meat" and "fat" pixels.
- Classify the "meat" pixels using the trained neural network The classification result is expressed as percentage of the tot number of meat pixels classified in each class.
- The overall decision to which class particular cut belongs made by taking into account the class with the highe resulting percentage.

RESULTS

An image of the cut surface of an LD muscle is shown in Figure 2, along with the results of colour classification of each pixel within this image show in Figure 3. The black pixels in figure 3 denote unclassified pixels, gray ones are classified as "meat" and white represent "fat" pixels. It is importa to note that there are three classes of pixel, so that background regions (groups of pixels that are not fat or meat) are not inadvertently classified "meat" or "fat". The $L^*a^*b^*$ values of the pixels classified as meat are than passed as input to the neural network for classification into seven class according to foreign authority meat colour standard. The results of the neural network classification for the meat cut shown on Figure 2 were as follows:

First colour class	0.0%
Second colour class	0.0%
Third colour class	0.0%
Fourth colour class	0.0%
Fifth colour class	17.72%
Sixth colour class	12.7%
Seventh colour class	69.58%.

Our system therefore classified the meat cut in Figure 2 as being most closely related to the seventh colour class in lean meat colour according to the colour standard. This agreed with our own subjective evaluation.

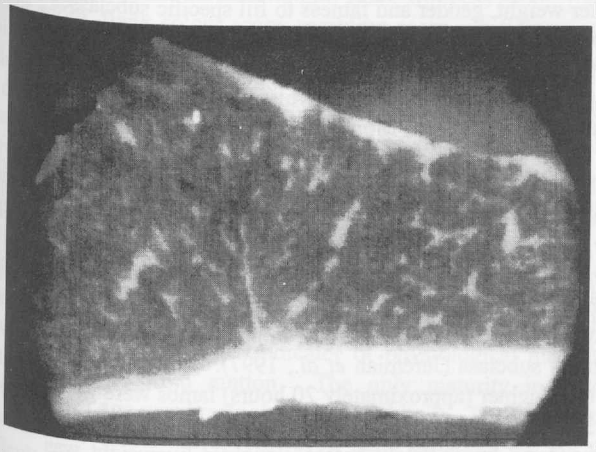

Figure 2.
An image of an beef LD muscle including intra-muscular and subcutaneous fat and background.

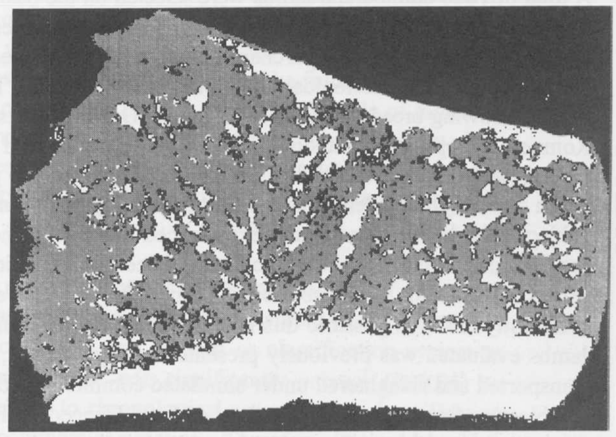

Figure 3.
Result of neural network classification. Black pixels represent "unclassified", gray "meat" and white "fat".

CONCLUSION

An objective, automated method for meat cut colour classification based on meat colour standards is presented. Preliminary results show that it is possible to implement machine vision approach to this, until now, highly subjective process. Further development is required to investigate the correlation between this objective measure of meat colour and other quality attributes, as well as with subjective human assessment. We also intend to extend the system to measure fat colour and marbling characteristics.

REFERENCES

[1] R. Clarke and A. Jelenak. "Towards Tri-stimulus Colour Measurement of Meat and Fat". *Image & Vision Computing New Zealand '96*, August 1996.