Meat Cut Classification

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INTRODUCTION

Modern meat processing plants use conveyors to transport meat cuts between processing stations. Consequently, there is a significant amount of manual sorting of meat cuts. Automation in identifying and sorting meat cuts can improve efficiency and effectiveness of the sorting and handling operations.

We have developed a prototype automatic system that can identify individual ovine primal meat cuts faster than one cut per second. The system consists of a digital line-scan camera, a monochrome frame grabber, a personal computer (PC), illumination and a conveyer. As meat cuts on the conveyer pass under the camera, they are automatically identified and classified. Overlapped and butted meat cuts are also identified.

A key to this automatic system is to design a set of good shape descriptors or features that can well discriminate different sorts of meat cuts. We have investigated a number of different kinds of shape descriptors, such as geometric, moment-based, log-polar, Fourier-Mellin, etc.[1],[2], but only the geometric shape descriptors are used in practice for reasons of simpler computation and efficient discrimination.

Meat cut classification involves four processes: image capture, image preprocessing, feature extraction and object classification. This paper describes the major algorithms used in this system for identifying ovine primal meat cuts.

IMAGE PREPROCESSING

Images of meat cuts are captured using a standard image capture software[3]. Before classification can be performed, an image must be filtered to reduce noise. We have investigated two methods for this purpose. The first is binary morphology[4] and uses dilation and erosion to remove sharp edges and small objects. The second uses the lowpass filter[5] to remove high frequency noise. Both methods are effective, but the lowpass filter method is more efficient. This is because this method still works well if the image size is reduced.

Using lowpass filter method in image preprocessing, there are four steps for noise reduction and object outline detection.

- The image size is shrunk to one-fourth of the original.
- The noise level is reduced using a lowpass filter.
- The grey-scale image is converted into binary using an automatic thresholding scheme based on the intensity histogram of the image.
- The 2D outline of the largest object (meat cut) in the image is extracted.

FEATURE EXTRACTION

This process requires the extraction of shape features or descriptors from the 2D outline of the meat cut(s). Since meat cuts vary in shape, scale, orientation and position in the captured image, the selected shape descriptors should be invariant to object scale, rotation and translation. We have investigated many different geometric shape descriptors and finally selected a set of five described below.

- Eccentricity --- the ratio of the width to the length of the bounding box
- Compactness --- the ratio of the area of an object to the area of the bounding box of this object
- Circle --- the ratio of the area of the internal circle of an object to the area of the object
- Quarto --- the ratio of the minimum object area to the maximum object area in four sub-boxes quarter-cut from the bounding box
- Octavo --- the area of the minimum object area to the maximum object area in eight sub-boxes three-folded from the bounding box

These shape descriptors can be visualised in Figure 1. The cuts shown are the leg, shoulder, leg and shoulder overlapped and two shoulders butted.

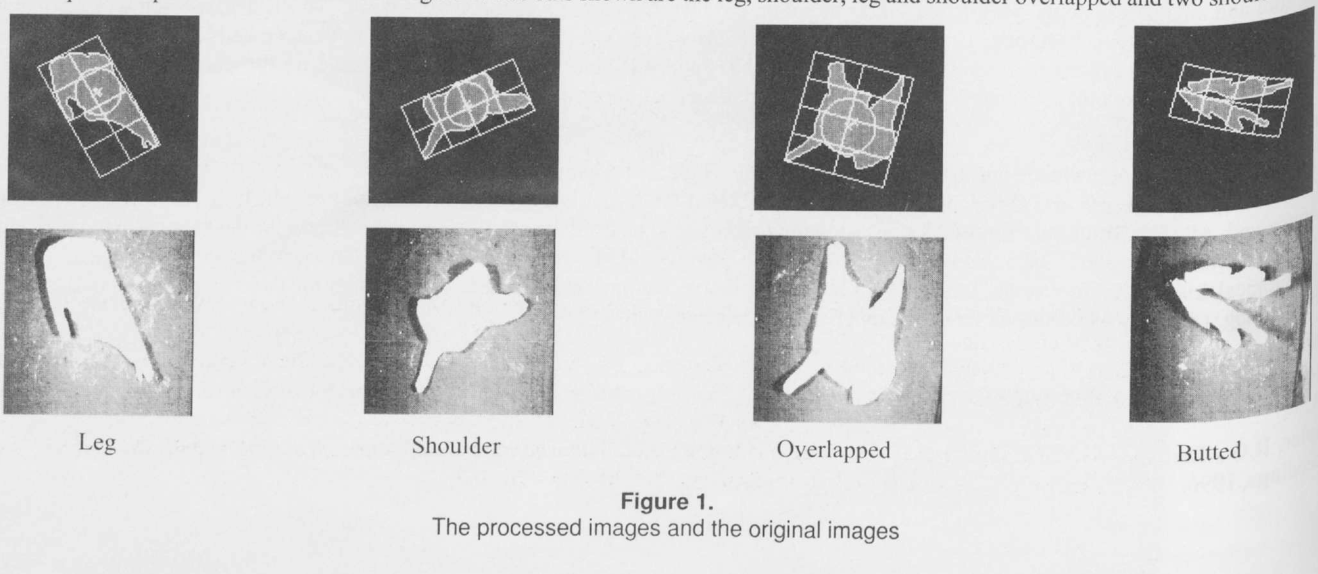

Figure 1.
The processed images and the original images

OBJECT CLASSIFICATION

Meat cuts are classified by matching the pattern of shape descriptors for the input meat cut(s) with those obtained from training. We have chosen four classes of ovine primal meat cuts: leg, shoulder, short loin and long loin for testing. Since overlapped or butted meat cuts have no similar shape, they are identified after their patterns do not match the pre-defined four classes. In general, many examples of meat cuts varied in size, translation and rotation in the same class should be trained to ensure success.

We have investigated several classifiers such as the linear, neural network and fuzzy logic[1],[2]. All three exhibited similar classification performance but the linear classifier was selected because of its lower computation overhead.

RESULTS

We have tested the above-described algorithms on more than 400 images of meat cuts. The success rates for classification are shown in Table 1.

Table 1.
Success Rate for Classifying Meat Cuts

Group No of Testing Images[1]	Number of Images	Category										Success Rate of Classification
		Legs		Shoulders		Short Loins		Long Loins		Overlapped or Butted		
		T[2]	C[3]	T	C	T	C	T	C	T	C	
1	96	24	24	24	24	24	24	24	24			100%
2	220	30	30	30	30	30	30	30	30	100	98	99%
3	32	9	9	7	7			7	7	9	9	100%
4	100	25	25	20	20			20	20	35	35	100%

1. Images in Group 1 were captured at MIRINZ in 1994. Images in Group 2 were captured at MIRINZ in 1995. Images in Groups 3 and 4 were captured at a commercial meat processing plant in late 1995/early 1996.
2. T means number of test images.
3. C means number of test images in which the meat cut(s) was correctly classified.

In a total of 448 testing images, only 2 images containing the overlapped meat cuts were not correctly classified. The reason was that their shapes were very similar to the shape of a shoulder meat cut.

We have also measured the processing time on the IBM PC with Pentium 75. The results are shown in Table 2.

Table 2.
Processing Times on the IBM PC with Pentium 75

Processing Step	Processing Time (s)
Preprocessing	0.79
Feature Extraction	0.17
Classification	0.0
Total	0.96

CONCLUSION AND DISCUSSION

We have developed an automatic classification system for identifying four different ovine primal meat cuts (leg, shoulder, short loin, long loin) and overlapped or butted meat cuts using any two of these. The test results have shown that the classification rate was greater than 99% for more than 400 test images. The speed for identifying meat cut(s) in every captured image was less than one second. The next step is to trial the system in an meat processing plant in New Zealand.

One great advantage of this PC-based system is that it is cost-effective. The shape descriptors are general in nature and can easily be modified to identify other meat cuts or objects.

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