A BEEF CARCASS CLASSIFICATION BY ON-LINE IMAGE ANALYSIS

J. Leclere[1], J.L. Bignon[1] and A. Lebert[2]
(1) Normaclass SA, 1 voie Félix Eboué, 94021 Créteil Cedex, France
(2) Station de Recherches sur la Viande, Centre de Clermont-Ferrand-Theix, INRA, 63122 Saint-Genès Champanelle, France

Introduction.

Visual assessment is a cheap method. It has become the principal component of the classification and grading schemes in many countries. The important factors influencing accuracy and consistency are /1/ the experience of assessors, /2/ the nature and the extent of the definitions of the differences between steps on the scoring scale, /3/ whether or not value judgement has to be made, /4/ the range and average level of the carcasses being assessed, /5/ how much the environmental conditions in which the assessments are made vary. A scale of 5 steps is usually too narrow for adequate discrimination between carcasses, while a scale greater then 10 steps is too wide for most people to operate successfully.

In Europe, beef carcasses are classified by visual inspection according to the EUROP scheme (Council Regulation 1208/81 and Commission Regulation 2930/81) regulated by the European Union (EU). This scheme is made up as follows: /1/ separate classification of conformation (in six classes: SEUROP) and fat cover (in five classes: 12345), /2/ when describing carcasses, the conformation classification is given first, /3/ for domestic purposes, member states may subdivide the basic classes: a 1-15 scale for fat cover (where 1 = very thin and 15 = very fat) or a 1-18 scale for conformation (1 corresponds to a very poor musculature and 18 to a very developed one), /4/ the conformation is defined by reference to 'profiles' with the muscular criterion being an optional extra element and /5/ the fat classification includes reference to fat inside the thoracic cavity as well as external fat cover.

This classification combined with the weight and the category (young bull, bull, steer, cow and heifer) is the basis for payment to the farmer. The meat plant's assessor who grades all the carcasses, is trained to grade according to the EUROP scheme. In order to maintain and control the classification system throughout the Union, a hierarchy of control agents was set up. But the EUROP scheme has some imperfections: the evaluation can be biased for a series of carcasses, the classifier's grading varies over time, there are systematic differences between classifiers or between classifier and the hierarchy.

In France, a grading system based on on-line image analysis was developed by Normaclass SA in order to grade beef carcasses according to the EUROP scheme. The aim of the project was /1/ to eliminate the imperfections of the visual inspection system and /2/ to develop the machine on the basis of a double-blind experimentation.

The Normaclass Machine.

As computer vision had become feasible in the mid-eighties, several countries have developed grading systems based on the concept of on-line image analysis: Australia, Canada, Denmark (European Patent 1987 and 1996), United States, Germany and France. In this last country, since 1985, Normaclass SA has developed a video system with first a scale machine, then a prototype and now a pre-industrial machine (European Patent 1991 and 1993). Several important data are extracted from the image: distances between some fixpoints, surfaces, volumes and the percent fat coverage. These data, combined with the weight, are used to predict fatness and conformation. The main characteristics of the machine are the following: /1/ it does not use a cabinet: a black background is used to eliminate the light from the surroundings, /2/ it uses six black and white cameras and a rotating frame in order to capture the carcass from different angles, /3/ it does not use insertion probes to estimate the fatness, which is determined by detailed analysis of the image, /4/ it measures the three-dimensional shape of the carcass by making images in three different angles (side view, three-quarter view and front view) /5/ the position of the machine on the conveyor enforces to make an upper and a lower view and /6/ the video analysis system uses the images to classify the carcasses including the most damaged carcasses. It can also predict the fatness and the conformation even if one or more cameras are out of order. The carcasses analyzed by the machine are dressed following the Commission Regulation 2930/81 recommendations, except for the tail and the thick skirt that are always present.

The Normaclass machine is integrated in the conveyor (see Figures 1 and 2) and is made of four parts: a rotating frame, a lighting system, six black and white cameras and a computer. The rotating frame captures first the right half carcass in a well-defined position; the side view of the inside is taken by the cameras. Then, after washing in order to prevent microbial cross-contamination, the frame captures the left half carcass; the three views of the outside are taken. The data treatment is made in less than 1 second. The machine can classify up to 120 carcasses per hour. When the frame is withdrawn, carcasses can pass through without touching any part of the Normaclass machine to prevent contamination. During the classification, the slaughterhouse personnel can not go through the area between the camera and the carcass. Four projectors are used in order to produce a sufficiently powerful and uniform illumination over the entire half carcass.

Experimental Design

In 1996, French authorities asked INRA to measure the performances of the machine. An experimentation was made in which carcasses were classified in conformation and fat cover at the level of a third of a class (in the EUROP scheme) by three experts (individual and common judgement), by two assessors (placed one before and one after fat trimming) and by the machine. To ensure an uniform classification over time and between different installations of the Normaclass Machine, experiments were made during eleven weeks in two slaughterhouses in order to have a representative set of "learning carcasses". Table I summarizes the number of carcasses analyzed during the experiments. All the experimental data are only in the possession of INRA.

Data were separated in five data bases: one for each category of animal. Each one was again divided in three parts: one for the learning, one for the validation and one for potential complementary studies. Table II shows the repartition of the carcasses of the five learning bases in the EUROP scheme. The common judgment of the experts for each carcass of the learning bases were transmitted to Normaclass in order to establish the relationships with data extracted from images. Normaclass transmitted, after the learning phase, the judgement of the machine on the carcasses of the validation bases. On these bases, two kinds of comparison were

made: assessors versus experts and machine versus experts for conformation and fat cover. Three criteria were defined to evaluate the performances of the machine or the assessors: /1/ for conformation, the percentage of carcasses well judged by the machine or the assessors in comparison with the experts, /2/ for conformation, the percentage of carcasses judged with a difference of a third of a class and /3/ for fat cover, the percentage of carcasses judged with a difference of a third of a class. French authorities defined the conditions to be satisfied by the machine: the above percentages of the machine had to be at least similar to the percentages of the assessors.

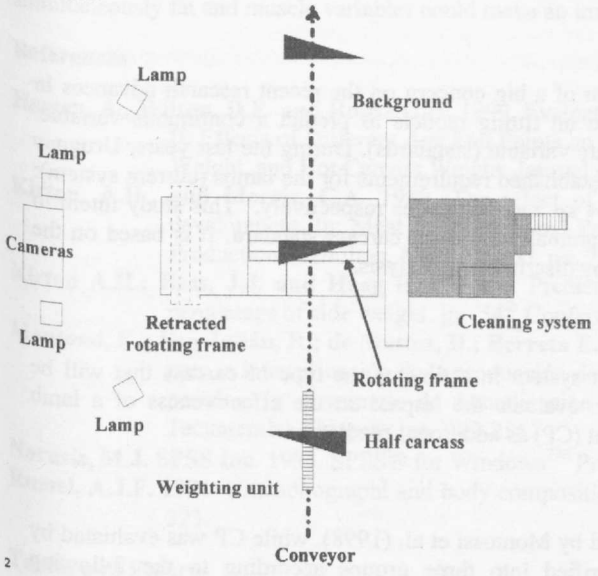

Figure 1 : Top view of the Normaclass Machine

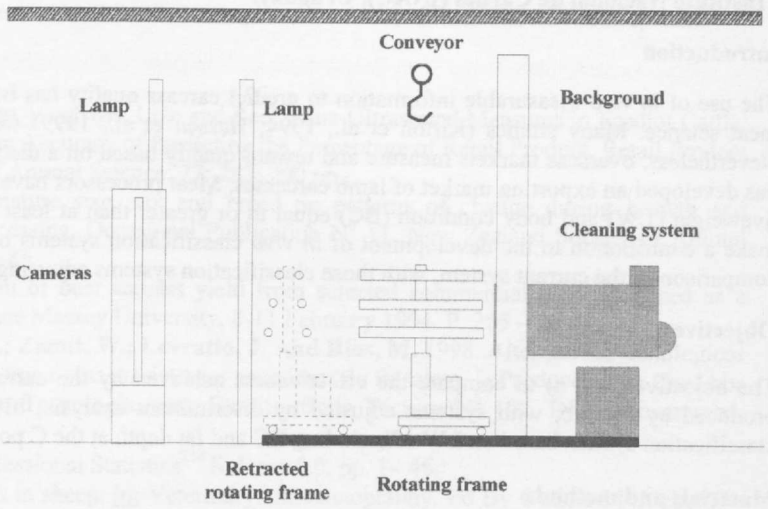

Figure 2 : Side view of the Normaclass Machine

Results

Table III indicates the results of the machine for the validation bases. As can be seen, the prediction is very satisfactory for conformation and satisfactory for fat cover: these results reflect also the variability of the human judgment. For conformation, more than 90% of carcasses were judged by the Normaclass machine in agreement with the experts or with a difference of a third of class. No difference greater than a class (in the EUROP scheme) was observed. In the case of fat cover, about 95% of the carcasses were judged by the Normaclass Machine with a maximum difference of two thirds of a class. No difference greater than five thirds of a class (in the EUROP scheme) was observed.

Table I – Number of carcasses analyzed in each animal category over the three years of the experiment

Year	Young Bull	Bull	Steer	Cow	Heifer	Total
1996	1 518	24	165	775	324	2 806
1997	1 538	38	371	1058	367	3 372
1998	106	5	69	292	540	1 012
Total	3 162	67	605	2 125	1 231	7 190

Table II – Repartition of the carcasses of the five learning bases

		Conformation						Total	%
		S	E	U	R	O	P		
Fat cover	1		1	1	5	8	69	84	4.3
	2	4	18	107	155	123	173	580	59.5
	3	6	33	254	358	236	197	1 084	55,0
	4		2	24	77	64	42	209	10.6
	5			1	4	7	3	15	0.8
Total		10	54	387	599	438	484	1 972	
%		0.5	2.7	19.6	30.4	22.3	24.5		100.0

Table III – Comparison between the prediction of the Normaclass Machine and the judgement of the experts on the carcasses of the five validation bases. Carcasses were classified in conformation and fat cover at the level of a third of a class

		Differences between Normaclass Machine and experts judgements (in number of third of a class)							Total
		0	± 1/3	± 2/3	± 3/3	± 4/3	± 5/3	± 6/3	
Conformation	Number of carcasses	437	274	65	6	1	0	0	981
	Percentage	44.50	48.11	6.63	0.61	0.00	0.00	0.00	100.00
Fat cover	Number of carcasses	244	426	231	68	10	2	0	981
	Percentage	24.87	43.43	23.55	6.93	0.01	0.00	0.00	100.00

References

European patent 0321981 B 1. EP, (1987). Danish Meat Research Institute, Roskilde.
European patent 0499550AL EP, (1991). Normaclass, Paris
European patent 0632960AL EP, (1993). Normaclass, Paris
European patent 96301383.4. EP, (1996). Danish Meat Research Institute, Roskilde.