AUTOMATIC GRADING OF SHEEP BY VISION

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Abstract

Development and testing of a new automatic vision based grading system for sheep is described. The VSS 2000 system consists of two cameras that capture one image of the right carcass side and one image of the back of the sheep carcass. 4359 carcasses were classified at the same time, in parallel and independently by the VSS 2000, the in-house classifier and two inspectors. 3770 carcasses were used for calibration and 689 used for validation tests. 220 of the carcasses used for calibration were deboned to find the primal weight and yield of the leg, rack, rib, shoulder and breast. Two repeatability tests were performed; one test to check if VSS 2000 gave the same conformation class and fat group when identical shaped carcasses were graded and the second test to control the repeatability between the in-house classifier, the two inspectors and VSS 2000. The calibration test showed that the VSS 2000 compares well with manual classification. The repeatability of VSS 2000 by far exceeds the human classifiers both for conformation class and fat group. The performance is better for conformation class ($R^2 = 0,77$) than for fat group ($R^2 = 0,70$). The accuracy of saleable meat estimation of the system gives the opportunity to use the system for sorting, production control and further processing.

Key words: vision, grading, sheep and lamb, saleable meat

Background

The Norwegian Meat Research Centre (NMRC) is responsible for training of classifiers, quality control and development of new carcass grading systems for pork, beef and sheep in Norway. Since 1931 grading of sheep in Norway have been performed by trained inspectors. The inspector decides category (lamb, hogg, ewe and ram), conformation class and fat group. The EUROP system was implemented in Norway in 1996. This system is a subjective grading system, but performed under strict specific rules the system can be described as an optimal subjective system. The EUROP system does as all subjective systems have a number of disadvantages. The most important disadvantage is the problem of inspector variation and the repeatability of each individual inspector or classifier.
Slaughterhouses annually receive a large number of complaints from the producers relating to the grading results. Because of this e + v Technology, GILDE Hedemark & Oppland Slaughterhouse and NMRC started in 1998 a project to investigate if vision could give a more objective grading of sheep carcasses compared with grading by trained classifiers. A more objective system for grading of sheep will provide more accurate value setting of the carcass, which will result in more correct payments to the farmers.

Current research has so far focused on pork and beef (Allen et al. 2000, Brancheid et al. 1998, Borggard et al. 1996, e + v Technology VBS2000 and VCS2000, Ferguson et al 1995, Madsen et al. 1999, Madsen et al., 1996).
In addition to the EUROP conformation- and fat class the VSS 2000 system gives the opportunity for primal weight-, primal yield- and saleable meat prediction, which gives slaughterhouses a better possibility for improved production control.

Objective

The objective of the work has been development and testing of an automatic vision based grading system for sheep carcasses.

Methods

The vision grading system (VSS2000) was placed at the end of the slaughter-line in conjunction with the weighing station. The carcasses were hung on Y-shaped hooks with both hind legs and transported with a line speed of up to 400 carcasses per hour passing the cameras. Two video cameras were placed approximately 2,5 meters from the slaughter-line with a blue coloured plate on the opposite side to maximise the contrast. The first camera took an image of the right side of the carcass (picture 1) followed by the second camera taking an image of the back (picture 2). The images were stored and analysed. To obtain results for a wide distribution of the sheep variety, assessments were done during the whole sheep season.

For the calibration a good distribution of the carcasses was needed to ensure that pictures of all the different conformation classes and fat groups were stored. 4459 carcasses were simultaneously and independently between each other classified by the VSS 2000, the in-house classifier and two inspectors. 3770 of these carcasses were used to create the calibration set during the 1999/2000 season. Another 689 carcasses were used to validate the system during the 2000/2001 season. 220 of the 3770 carcasses were deboned to find the primal weight and the saleable meat (yield) of all primals (legs, rack, rib, shoulder and breast). The data was recorded and compared to saleable meat estimation done by the VSS 2000.
A repeatability-test was performed to check if VSS 2000 gave the same conformation class and fat group when identical shaped carcasses was graded. The same carcass was classified twice by VSS 2000 to give the same result within a twenty seconds interval for 27 carcasses. In addition to the above mentioned tests 36 carcasses were classified three times within a time frame of approximately 1,5 hour by the in-house classifier, the two inspectors and VSS 2000. The results are shown in table 4.

Results and discussion

Table 1 Results from the calibration test (R^2), 15 point EUROP-scale

	R^2 conformation class	R^2 fat group	Syx conformation class	Syx fat group
All categories (n = 3770)	0,77	0,70	0,71	0,90
Lamb (n = 3328)	0,84	0,65	0,58	0,83

Because of the different results between all categories and a specific category (lamb), the system will be installed with category specific equations.

Table 2 Results from the validation tests (R^2), 15 point EUROP-scale

R^2	validation test 1 (n = 480)	validation test 2 (n = 209)	between the two inspectors		between inspectors and in-house classifier	
			(n = 480)	(n = 209)	(n = 480)	(n = 209)
Conformation class	0,87	0,83	0,79	0,84	0,71	0,77
Fat group	0,68	0,65	0,78	0,82	0,59	0,78

Table 3 Primal weight, STD, correlation (R^2) and Syx between estimated weight by VSS2000 and deboned weight (n = 220).

Primal	Estimated mean (kg)	STD	R^2	Syx
Legs	5,75	1,38	0,98	0,18
Rack	2,27	0,70	0,96	0,14
Rib	2,18	0,70	0,94	0,18
Shoulder	3,23	0,78	0,97	0,13
Breast	3,61	0,98	0,97	0,17

The Repeatability-test of the VSS 2000 system showed a $R^2 = 0,97$ for conformation class and $R^2 = 0,97$ for fat group (n = 27).

Table 4 Repeatability test (R^2) of VSS 2000 and the two inspectors (n = 36)

	test 0 / test 1		test 0 / test 2		test 1 / test 2	
	conformation	fat	conformation	fat	conformation	fat
VSS 2000	0,91	0,85	0,86	0,81	0,92	0,97
Inspector 1	0,89	0,75	0,82	0,71	0,85	0,84
Inspector 2	0,67	0,78	0,74	0,79	0,77	0,83

The reliability of the system is high. Only a few carcasses, which have been deformed during slaughter and dressing needs to be classified separately by the in-house classifier. During the repeatability test it was observed that carcass temperature and time after post mortem both affect the fat class grading of the system. This problem will be solved y making constant the time between killing and grading. During the test it was not possible for the system to predict the category. Further tests are planned to be able to predict the category.

Conclusions

The repeatability test shows the advantage of the system compared to the inspectors for conformation and fat class prediction. The accuracy of saleable meat estimation of the system gives the opportunity to use the system for sorting, production control and further processing. Further tests for solving the carcass temperature problems to make the system more robust are planned.

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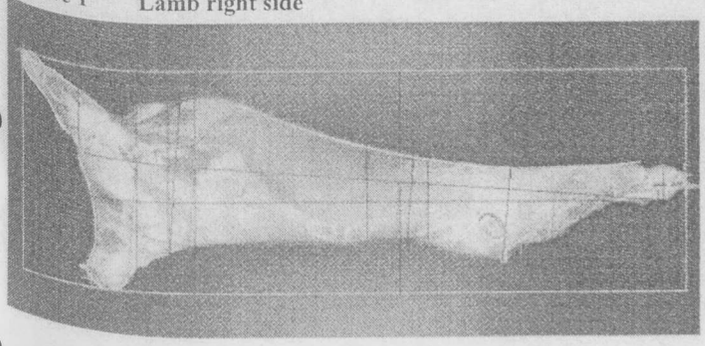
Picture 1 Lamb right side



Picture 2 Lamb back