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Assessing Udder Cleanliness with an Image Processing System

An industrial image processing system for assessing optical parameters was used to measure udder cleanliness. Surface conditions were defined by luminance and red-cyan and yellow-blue colour combinations. The number of pixels on dirty and clean surfaces differed significantly (P<1%). The surface status could be detected using dependable limiting values for maximum pixels on clean surfaces. To calculate reliable limiting values and improve measuring conditions through rigid cow positioning and optimal udder illumination, more research is necessary.

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Keywords

Udder, cleanliness, image processing

Automatic milking systems actually are not able to evaluate the status of cleanliness of udders and to detect lesions of teats to manage cleaning of udder and teats according to the demands of actual regulations.

Results of basic research on application of optical parameters to fulfil these demands have been presented by [1]. Problems were mainly found with respect to pigmented surfaces. In a further step, [2] used a CCD-colour-camera to evaluate the cleanliness of teat surfaces. Correct recognition of dirty teats was possible by connecting type and intensity of colours of all pixels.

Analysis of spectroscopic parameters according to an industrial standard to evaluate the efficiency of cleaning udders and teats indicated that manual cleaning mainly caused modifications of luminance of surfaces [4]. The parameters red/green and yellow/blue were not useful to indicate cleaning efficiency at white surfaces, but a significant reduction of the level of „yellow" due to cleaning was observed at black surfaces. The parameter red/green was most efficient to detect bloodstained surfaces. It was concluded that for practical application a remote sensing system based on video cameras would be more useful than the device used in this investigation requiring direct contact with the surface to be evaluated.

Material and Methods

In a first experiment in two recording sessions an industrial image processing system (Manufacturer: ISRA-Vision systems, Karlsruhe, D) was used to collect information about optical parameters to indicate the cleanliness of udder surfaces of ten cows, housed in an experimental stanchion barn at the Federal Agricultural Research Centre (FAL) at Brunswick. In each session two sequences of images were produced. The initial sequence represented clean surfaces, the second sequence was recorded after controlled application of faecal material.

The data recording system produced three parameters, Y, U, V, to describe the optical condition of the evaluated surface, using the numeric range from 1 to 255, corresponding to an 8 bit data transmission system [5]. The parameter Y indicates the luminance. The chrominance signals U and V indicate the balances of red-cyan (parameter U) and yellow-blue (parameter V). A white object is represented by the values of 255 (Y), 127 (U) and 127 (V). The Y-U-V colour model used here is written down in the standard CCIR-601, dealing with conditions for transmission of colour video signals.

The image processing system applied offers two ways for setting the critical limits for the parameters. The more practical proposal is to select critical points at the image shown at the screen, using the pointing device of the computer („mouse"). The range of parameters to characterise corresponding areas then is set automatically by the software. Another option is to enter the limits numerically by the keyboard which can be useful to reduce „false positive" or „false negative" indications.

Images of the rear part of udders were recorded by a CCD-camera which was placed on a trolley, also equipped with two 55 W halogen-lights to obtain stable illumination of the respective udder surface. Due to their triangular arrangement the light beams indicated the central area of the image to be recorded, simplifying a correct placement of the camera with a distance of about 1.5 m behind the cow.

The evaluation of images was based on four conditions of surfaces to be found: dirt, white, black, shadow/contour. The last mentioned situation was included into the analysis, because initial tests have shown that the signals corresponding to unclean surfaces to a certain amount may also be found at clean

Table 1: Ranges of the optical parameters

	Average values					
Surface	Ymin	Ymax	Umin	Umax	Vmin	Vmax
Dirt	46,4	78,3	111,7	123,3	133,7	139,1
White	92,6	150,8	112,2	123,4	136,3	151,2
Black	25,1	51,5	126	131	128,7	133,1
Shadow	55,7	74,8	122,8	131,5	132,6	143,3

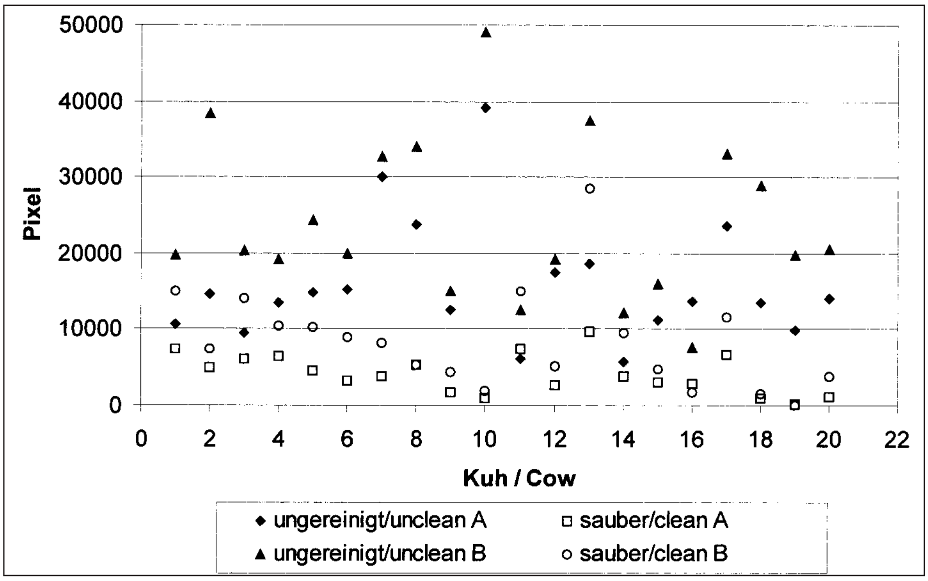

Fig. 1: Presentation of unclean and clean surfaces with settings A and B

areas due to poor illumination, caused by the movement of the cow or at some parts of outlines of udder or legs. Similar observations were mentioned by [2].

Ten images of unclean udders recorded in the first session were used to define the range of the optical parameters to be used for evaluation of the status of surfaces (*Table 1*), corresponding to the averages of lowest and highest values resulting from the teaching procedure.

Evaluation of surfaces was done in two ways, using the most frequent values of all parameters, based on visual inspection of images (Setting A) and using the averages of the parameter Y in combination with the most frequent values for U and V (Setting B).

For statistical treatments F-test and range-test according to Newman-Keuls (e.g. Haiger [3]) were used.

Results and Discussion

The total surface evaluated included 391554 pixel per image. In *Table 2 and 3* the amounts of pixels are given, obtained at different types of surfaces in unclean and clean condition. Both settings for evaluating the parameter „dirt" produced corresponding results. The amount of pixels found at unclean and clean surfaces differed in a highly significant way (P<1%). A significant difference between unclean and clean surfaces also was found for the parameter „white", while for „black" an „shadow" no difference between unclean and clean surfaces were to be seen.

It was possible, as shown in *Fig. 1*, to identify unclean and clean surfaces with both settings for the parameter „dirt", using limits for the amount of pixels representing this parameter not to be exceeded by clean surfaces. Using setting A, the critical limit could be set at 10000 pixels, with setting B a limit of 15000 pixels seemed to be more appropriate. The limits corresponding to setting A produced less false results than setting B.

Similar to results presented by Ordolff [4] also in this investigation luminance (Y) was the most variable parameter. However, the figures representing the structure of colours at surfaces evaluated indicate that only the application of all parameters can lead to a reliable decision to what extend cleaning the udder is necessary and whether it was done efficiently.

Based on only 20 recordings it would be too early to set general limits for clean and unclean surfaces, especially with respect to the questions about shading effects as described by [2].

Visual inspection of images indicated, that not all cows were in identical position when clean and unclean udders were to be recorded. This situation, already mentioned by [2], may explain some of the irregular results to be seen at *Fig. 1*. For practical application of the system, the relative position of the camera and udder therefore is to be stabilised, e.g. by using the signals to be obtained by sensors for monitoring the cow position, included in most automatic milking systems.

While shading, found to be a problem by [2], in the investigation described here did not affect the efficiency of classification of unclean and clean surfaces, it should be avoided by optimised illumination of udders. Since evaluation of the total udder surface requires at least two cameras this problem may be solved by adapting illumination individually to the surface inspected by the respective camera. This also could be the way to avoid irregular classification of contours.

Summary

The analysis of images of unclean and clean surfaces of udders, recorded in two sessions with an industrial image processing system, indicated, that the combination of luminance and chrominance allowed setting limits to recognise with some certainty unclean and clean surfaces. For practical application, however, more investigation is required to analyse additional aspects like positions of cows, adding cameras for evaluation of full udder surfaces and optimisation of illumination of surfaces to be checked.

	Dirt (Version A)		Dirt (Version B)	
	dirty	clean	dirty	clean
Average value	15890	4127	24011	8372
Standard dev.	7866	2522	10253	6400
F	38,52		31,81	

Table 2: Dirt (pixel) found at evaluated surfaces

	Surface type					
	white		black		shadow	
	dirty	clean	dirty	clean	dirty	clean
Average value	104769	143622	79028	70772	12218	11712
Standard dev.	35460	55422	41876	49741	7722	7148
F	6,63		0,31		0,04	

Table 3: Other optical conditions (pixel) of evaluated surfaces

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