A new tool for beef performance recording in Italy

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Introduction

Reliable performance recording on beef cattle is required for selection and extension services; in addition accurate recording of animal performances is the core for the estimation of the genetic merit of animals for economic and/or relevant productive traits, and is the basis for farmer's evaluation of his management (producing animals with the best possible conformation, as efficiently as possible).

Particularly, live weight is a key recorded trait in beef production, and it is normally recorded using a scale. Especially in extensive beef cattle management systems, live weight is difficult to be recorded directly, either because scales are available only in some farms or mobile scales are difficult to transport and install. Also beef animals reared in extensive farm are difficult to kept and manage.

To overcome these difficulties an alternative option of estimating body weight has been investigated, validated and used in Italy, exploiting the high correlation between chest circumference and body weight. Chest circumference of animals, taken using a measuring tape, may be indeed used as a proxy trait for growth traits in beef performance recording: particularly, live weight can be estimated from chest circumference using a conversion formula that includes both the age of the animal and its chest circumference. Conversion formulas are specific for animal's breed and sex. To be correctly measured by tape, however, animals need to be immobilized: this step is time consuming and often a source of stress on both animal and operator, especially in extensive system, where animals are minimally handled and thus not used to be close to human operators. Immobilizing animals is not sufficient to create a safety environment and guarantee full operator's security during the chest measurement by tape.

Italy has several native beef breeds as Chianina, Marchigiana, Romagnola, Maremmana Podolica, and Piemontese, most of them worldwide recognized for the quality of their production. They are strong, rough and long-living breeds, adapted to different climates and bred easily in a confined rearing system as well as in an open herding or a semi-open herding system. It is indeed of major interest for Italian Breeders Association and Italian Beef Cattle Herd book to record live weight, mandatory to achieve the selection goals in a simpler, faster and more economic way as possible. Live weight estimation by chest girth recording is a solution for these peculiar situations. In Italian beef performance recording activity, chest circumference recording is largely used because it reduces time and costs of recording activity and allows to save on the scale cost, calibration included.

Research

Since 2005, A.I.A. financed a team of experts (engineers, farmers, animal scientists, veterinarians) working on estimation of chest circumference by opto-electronic devices. Mauro Fioretti (A.I.A.), member of former ICAR Beef Working Group, during the meeting held in Kuopio (Finland) in June 6th, 2006, reported the research progress in developing such a system. Technically it consisted in a video recording of the animal, that led to a raw volumetric picture of an animal itself and its weight estimated by a proprietary algorithm.

The problems occurring with this system were basically the high final device cost, the difficulties for the final user to get correctly the frames and the lack of automatic measures taking. In the last two years, boosted by technological development, a new research line come up towards the production of a simpler and user-friendly device. The new device is based on a standard digital camera, connected to a notebook and equipped with two laser pointers. Exploiting an high performing proprietary algorithm, it is now sufficient to take a series of raw images of an animals on which is possible estimate a highly reliable chest girth

The new device – how it works

The equipment implements a new method to decode picture collected from by a cameras for the estimation of chest circumference through a patented software and using the projection of a laser pattern to rescale the measure according to the distance between the operator and the tagged animal.

The system integrates a GPS for geographical location, a laser generator, a digital camera, an operator interface and a computerized control unit (connected to all devices). Measures on "free" (not tied) animals, aimed to maximize both operator's safeness and animal comfort. The advantages consist in getting a high repeatable measure in real time, minimizing recording times. The device is ergonomic, shock resistant, waterproof and user friendly, consisting basically in the use of a digital camera. No contact with animals are required, and by a zoom lens even distant animals can be recorded.

The software elaboration system, using advanced image processing algorithms, is portable, and data are transmitted by wired or wireless connection. A synthetic vocal interface is used to identify animals and to guide the operator in taking sufficient images for chest girth estimation. The recorded images will be watermarked with time and date of the creation of the image and with the actual GPS location.

The use of the device is rather simple: an animal in paddock or pasture or box is chosen to be measured. Animals ID are preloaded in the notebook and the vocal synthesizer pronounces on the earphone the preloaded IDs. When the right ID is pronounced, the operator pushes a button and the system gets ready for image taking and processing of the specified animal. The system is then ready for recording. Laser beams are projected on animal's surface and are visible as two light points. These laser points (fig. 1) are detected by the digital camera's system that focuses on the animal part in which laser points are.

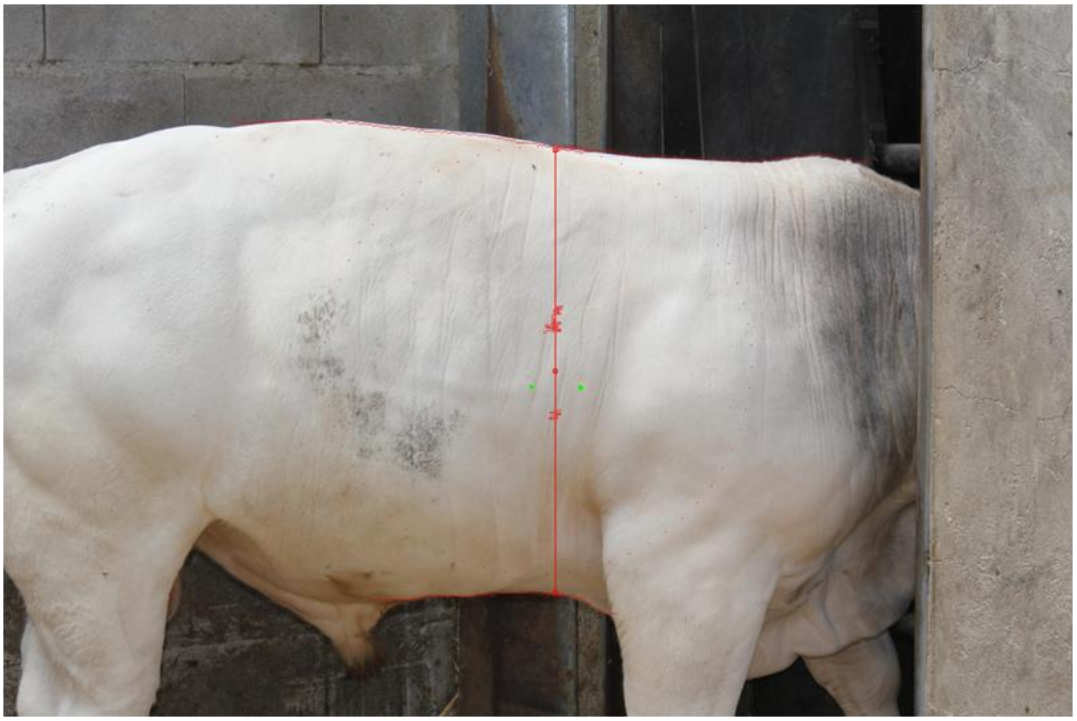


Figure 1. Example of laser points (in green) projected on animal's surface

A synthetic voice from the system asks via earphone to take a picture. The operator starts taking several front and side images of the animal, and for each image an estimation of chest girth is produced. Every time a new picture is taken, the software automatically estimates a new measure for the side/front axis and a new chest girth is estimated. The way the images are processed in this stage are reported in fig. 2.

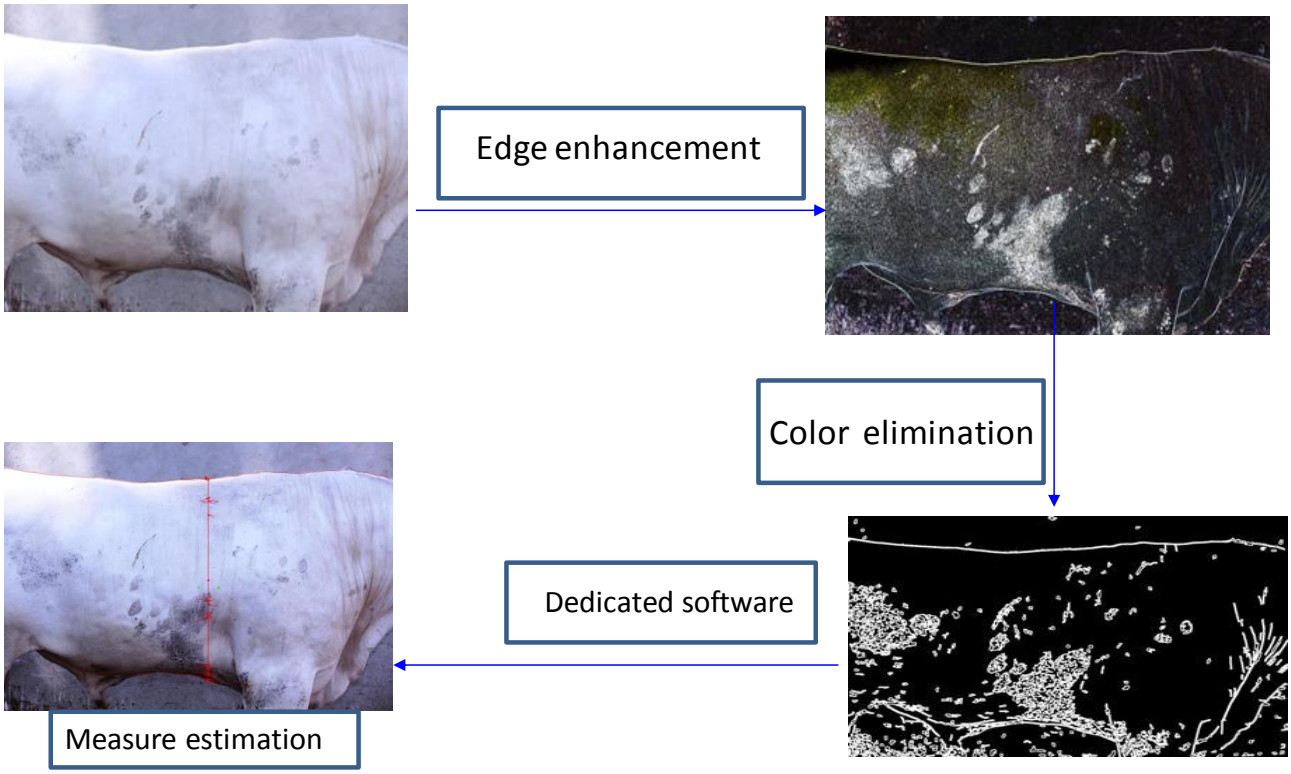


Figure 2. Image processing phases by the software

Chest girth estimation is made using the horizontal (from front image) and the vertical (from side image) as axis of an ellipse, as reported in figure 3. The ellipse length, i.e. the chest girth, is then calculated.

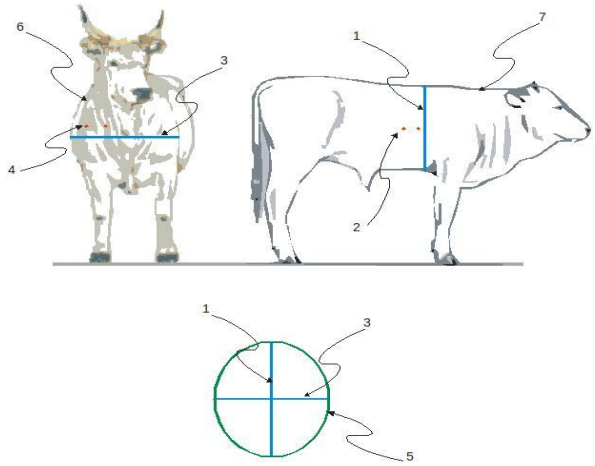


Fig. 3. Chest girth estimation from measures coming from processing of front and side images.

The variation coefficient of the n^{th} respect to $(n-1)^{th}$ measure is calculated; when a convergence criterion is met, then there is no need for further digital images: when this occurs, the system tells to the operator via earphone to stop taking pictures. In Appendix A a real example of how the measure is calculated by the software is reported.

Pictures are then stored in the computer and watermarked with GPS location, animal ID, date and time; Estimated measures are stored too. All data are then sent to national central database (A.I.A., Rome). Estimated chest girth (expressed in cm) is transformed in live weight (kg) basing on A.I.A.'s algorithms working by breed, sex and animal age at test following ICAR's guidelines.

To resume, the presented system is formed by handy and ergonomic devices, has an accessible price and need few and simple rules to be followed. It allows to achieve maximum operator's safety together with fast recording and high repeatability of measures. The production of non modifiable and geo referenced images for the recorded animals allows the creation of a multimedia database available for further researches and developments (biometric measures, etc). The system has been patented by A.I.A. Next to come improvements will interest proprietary software downsizing, in order to adapt it to Linux operative systems and Android: in this case, a simple Smartphone will allow to have in the same device a digital camera, an image processing software and data transmission tools in real time.

Main results from on field activity

On field tests were performed in a performance test center (ANABIC) and in a farm belonging to CRA (Ministry of Agriculture research center for meat production).

Work conditions

The device was tested on Chianina, Marchigiana, Piemontese and Maremmana animals of both sexes. Each animal was identified and its chest girth (centimeters) and live weight (kilograms) were recorded using respectively a metric tape and a scale. For each animal up to 20 front and side digital photos were taken using a digital camera. Two parallel laser beams

installed on the camera (green points) were projected on the animal and used both as distance and metric indicators. The images were automatically and incrementally processed by a dedicated software and an estimate of chest girth was produced. Such estimates were compared with the tape measure.

Results

Table 1 reports the real and automatically estimated chest girth for 20 animals. The difference between real and estimated measure was calculated for each animal. The average difference was -0.16%, with a standard error of 1.04%, a minimum of -3.06% and a maximum of 1.55%. For overestimated chest girths the mean difference value was -0.77% with a standard deviation of 0,84%, minimum of -3.06% and maximum of -0.6%, while for overestimated girths the mean difference was +0.76% with a standard deviation of 0.46%, minimum 0.15%, maximum +1.55%.

Animal ID	Breed	Tape chest girth	Estimated chest girth by opto-informatic device	Farm	Difference tape - estimated chest girth (% on tape)	Difference tape - estimated chest girth (% on tape) <0	Difference tape - estimated chest girth (% on tape) >0
88	Marchigiana	194.0	197.0	Anabic	1.55%		1.55%
89	Marchigiana	195.0	193.8	Anabic	-0.62%	-0.62%	
90	Marchigiana	193.5	191.2	Anabic	-1.19%	-1.19%	
91	Marchigiana	191.5	192.9	Anabic	0.73%		0.73%
94	Chianina	200.5	202.6	Anabic	1.05%		1.05%
97	Chianina	204.5	204.8	Anabic	0.15%		0.15%
98	Chianina	202.0	202.5	Anabic	0.25%		0.25%
104	Chianina	196.0	195.4	Anabic	-0.31%	-0.31%	
106	Chianina	203.0	202.0	Anabic	-0.49%	-0.49%	
109	Chianina	191.0	190.8	Anabic	-0.10%	-0.10%	
7997	Chianina	192.0	190.9	CRA	-0.57%	-0.57%	
8002	Chianina	170.0	171.9	CRA	1.12%		1.12%
4651	Chianina	177.0	178.0	CRA	0.56%		0.56%
8028	Chianina	172.0	173.2	CRA	0.70%		0.70%
4669	Piemontese	175.0	173.0	CRA	-1.14%	-1.14%	
7970	Piemontese	164.0	163.9	CRA	-0.06%	-0.06%	
8082	Piemontese	160.0	155.1	CRA	-3.06%	-3.06%	
4643	Maremmana	187.0	186.2	CRA	-0.43%	-0.43%	
7968	Maremmana	185.0	182.7	CRA	-1.24%	-1.24%	
8015	Maremmana	172.0	171.9	CRA	-0.06%	-0.06%	
				Mean	-0.16%	-0.77%	0.76%
				St. Dev.	1.04%	0.84%	0.46%
				Min.	-3.06%	-3.06%	0.15%
				Max.	1.55%	-0.06%	1.55%

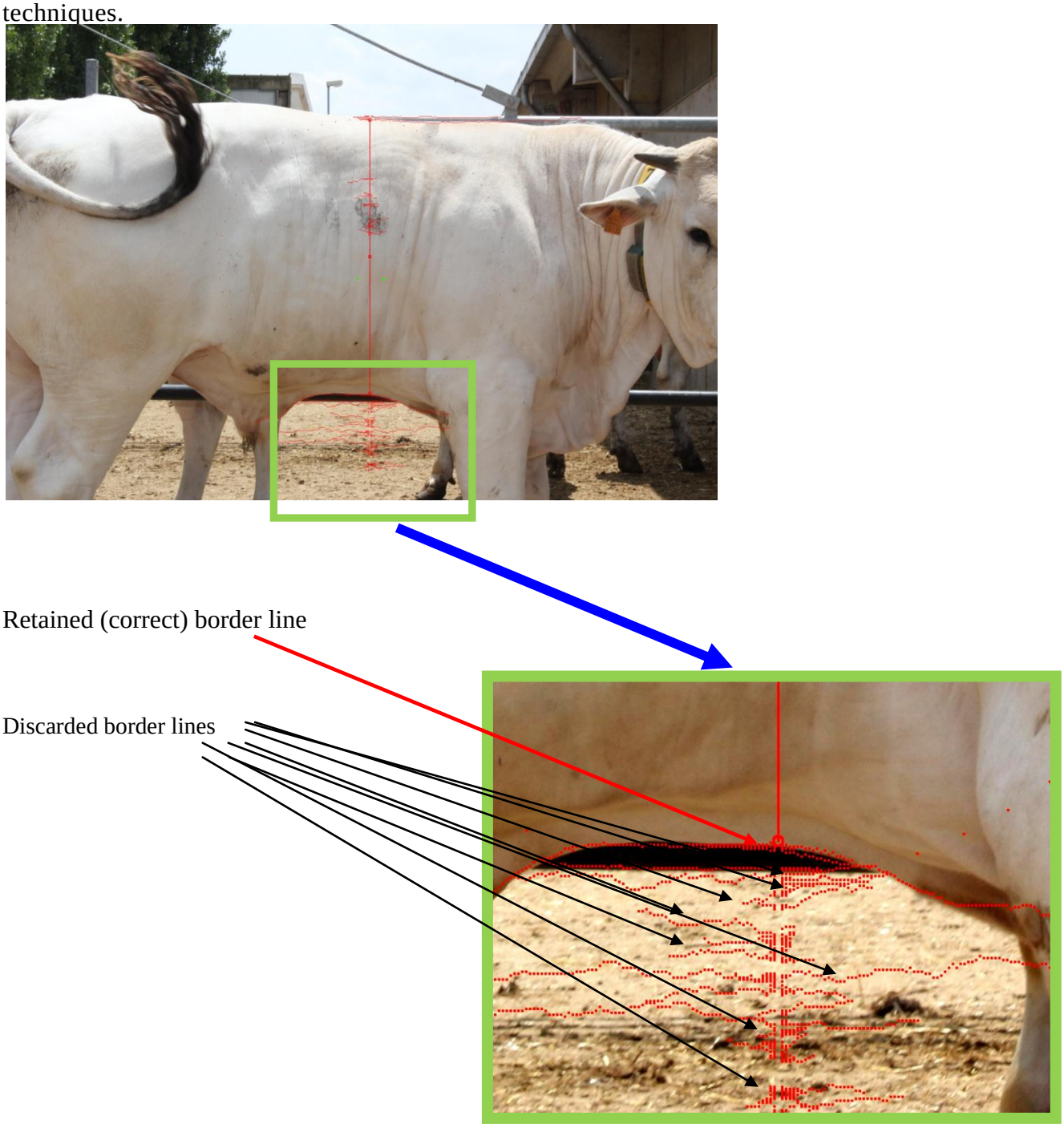
Table 1. Estimated and real chest girth measures in a field trial

These results show that, on the average, the system has a high precision in estimating chest girth.

Appendix A.

Automatic noise filter

In the following image it is clearly showed how the software identifies all the possible border lines. This is a typical situation occurring with tubular fences, ground or grass floor, poor light or exposition, coat pigmentation, mud on coat, and so on. The software is able to discard the image "noise" in field situation (e.g. mistaken border lines) using efficient pattern matching techniques.

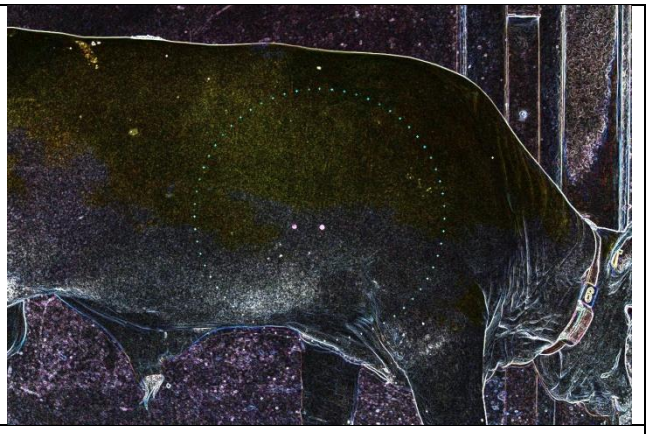


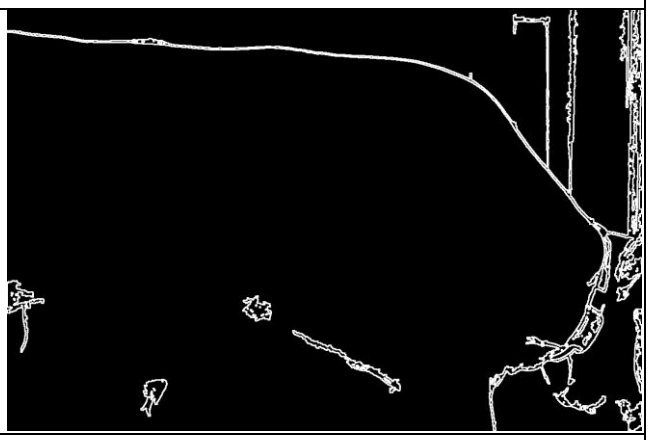
Automatic mistakes exclusion

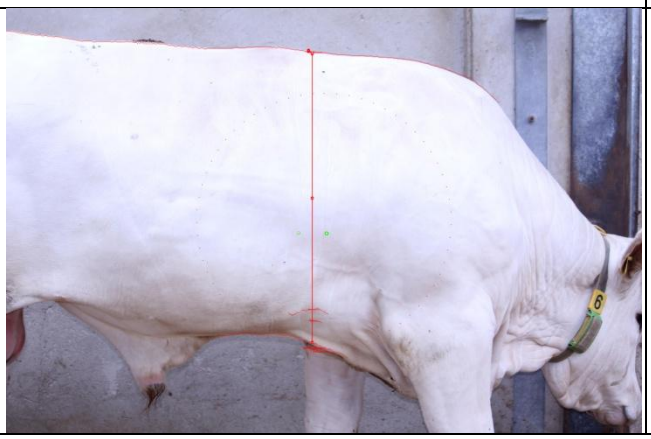
The automatic system for image processing elaborates in incremental way all the photos taken by the operator. In other words, each image is used by the software to increase the precision of the estimated measure. During this process, the system informs by synthetic voice the operator about the processing result and possible anomalies regarding the image quality. The following example can be used to better explain the process.

The animal is a Chianina male, aged 383 days in the recording date. Its chest girth, recorded using a measuring tape, is 203 cm.

First image processing:



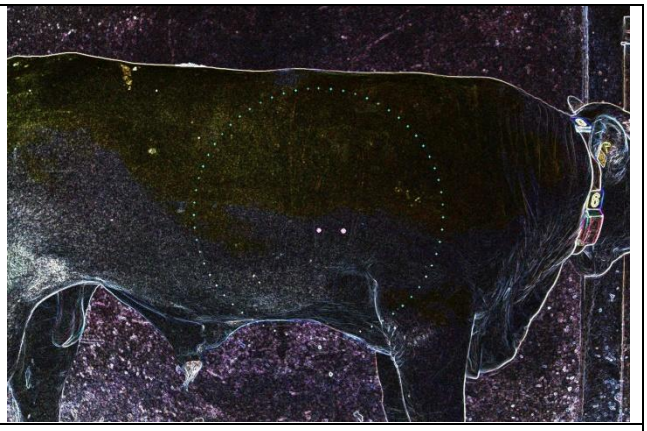




First estimation:

- Vertical axis: 74,6 cm
- Horizontal axis: 52,4 cm
- Estimated chest girth: 205,1 cm
- Estimated live weight: 635 kg

Second image processing:

<table>
<tr><td>  </td><td>  </td></tr>
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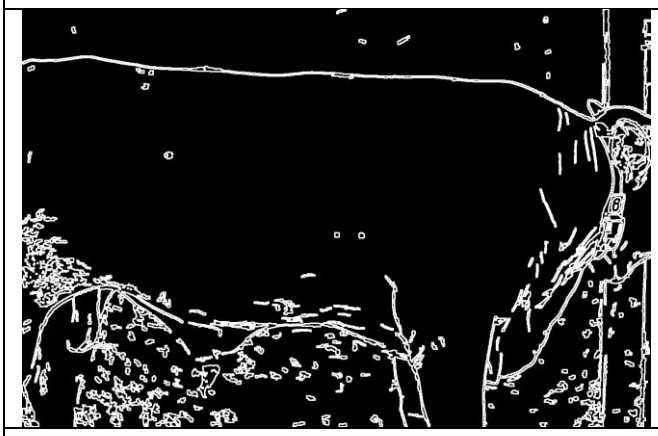
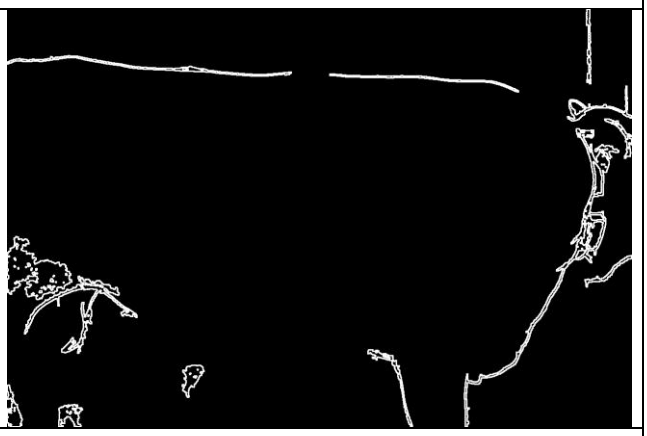
<tr><td>  </td><td>  </td></tr>
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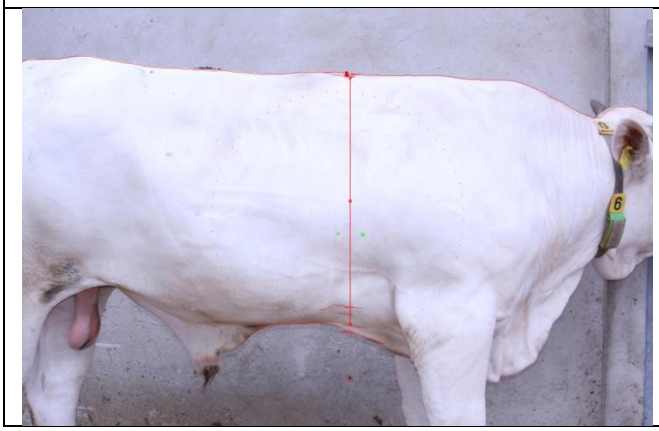
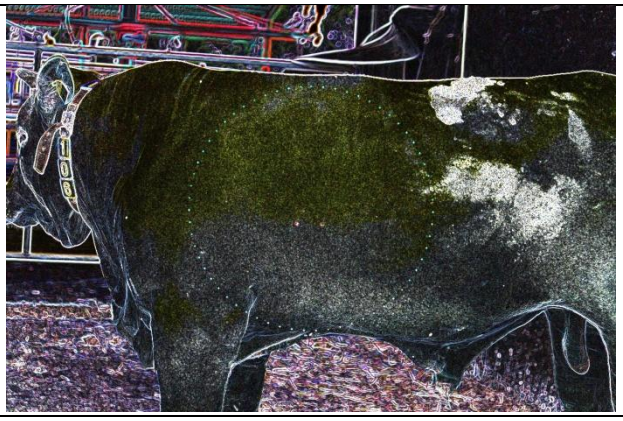
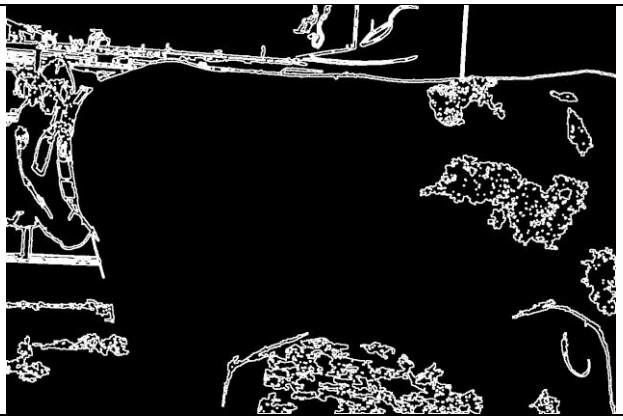
<tr><td>  </td><td>Second estimation:
Vertical axis: 73,2 cm
Horizontal axis: 51,4 cm
Estimated chest girth: 201,2 cm
Estimated live weight: 611 kg</td></tr>
</table>

Third image processing :

The system tells the operator that the image he took in this moment has been discarded since the laser pattern was not correctly recognized. This occurs e.g. when the operator cover with his hand one or all the laser emitters.

Fourth image processing:



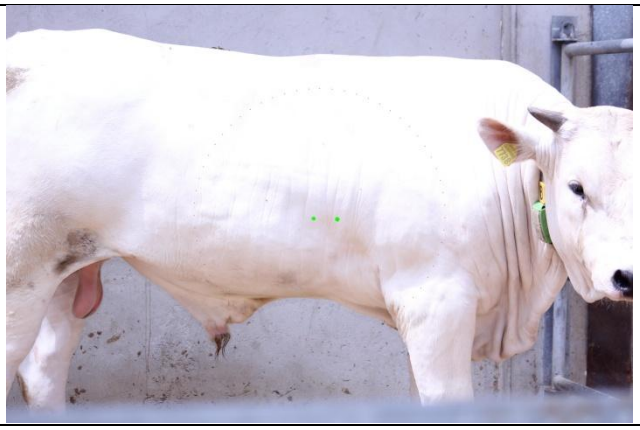


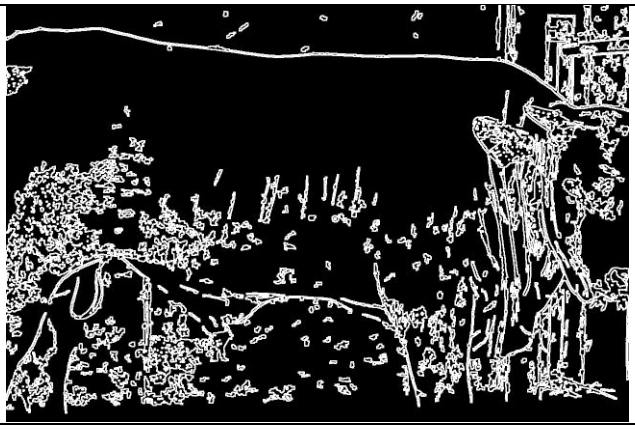
Fourth estimation (inalterata):

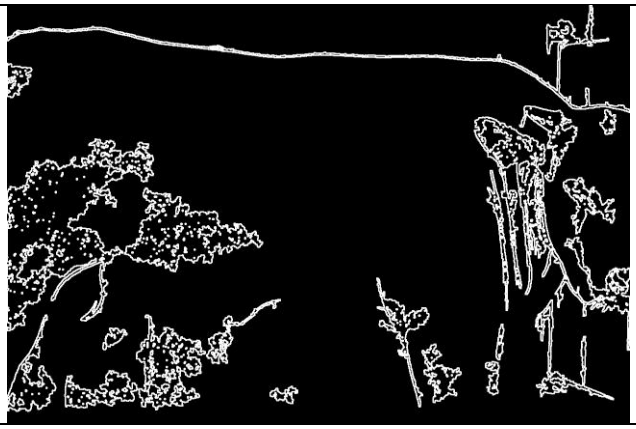
- Vertical axis: 73,2 cm
- Horizontal axis: 51,4 cm
- Estimated chest girth: 201,2 cm
- Estimated live weight: 611 kg

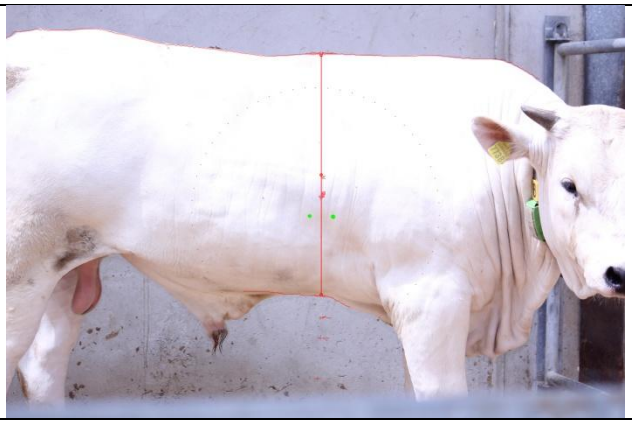
In this image the tubular fence has been correctly discarded when selecting the upper border line. Unfortunately, when finding the lower border line, the system is confused by the straws on the floor. Vertical axis estimated is 82 cm, but the system discards such measure maintaining the previous estimates.

Fifth image processing:









Fifth estimation :

- Vertical axis: 73,1 cm
- Horizontal axis: 51,4 cm
- Estimated chest girth: 201,0 cm
- Estimated live weight: 610 kg

Sixth image processing:

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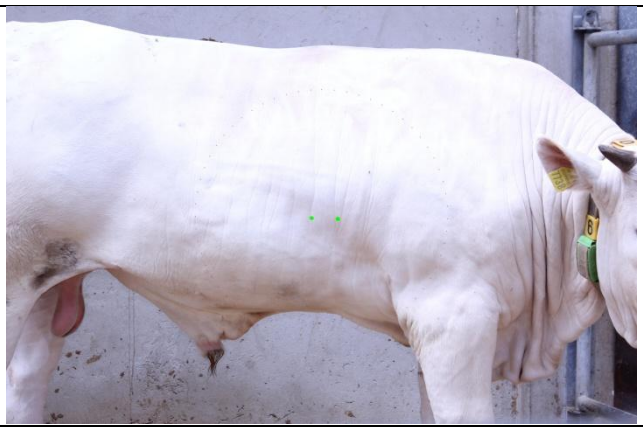
<tr><td>  </td><td>  </td></tr>
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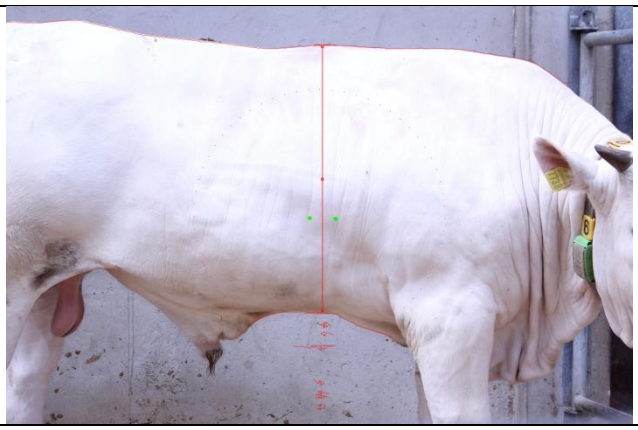
<tr><td>  </td><td>Sixth estimation:
Vertical axis: 74,0 cm
Horizontal axis: 51,6 cm
Estimated chest girth: 202,0 cm
Estimated live weight: 616 kg</td></tr>
</table>

At this point the data meat the convergence criteria and the system considers the measure stable and reliable. The entire process duration was about 5 minutes. The final estimated chest girth was 202.

Immediately the system is ready to measure another subject.