Visual Analysis of Morphological Features of Live Cattle From RGB-D-T Data

João Paulo Gomes Penha, Pablo Ricardo Roxo Silva, Luciano Rebouças de Oliveira
Intelligent Vision Research Lab
Federal University Of Bahia
Salvador, Brazil
Web page: http://ivisionlab.dcc.ufba.br

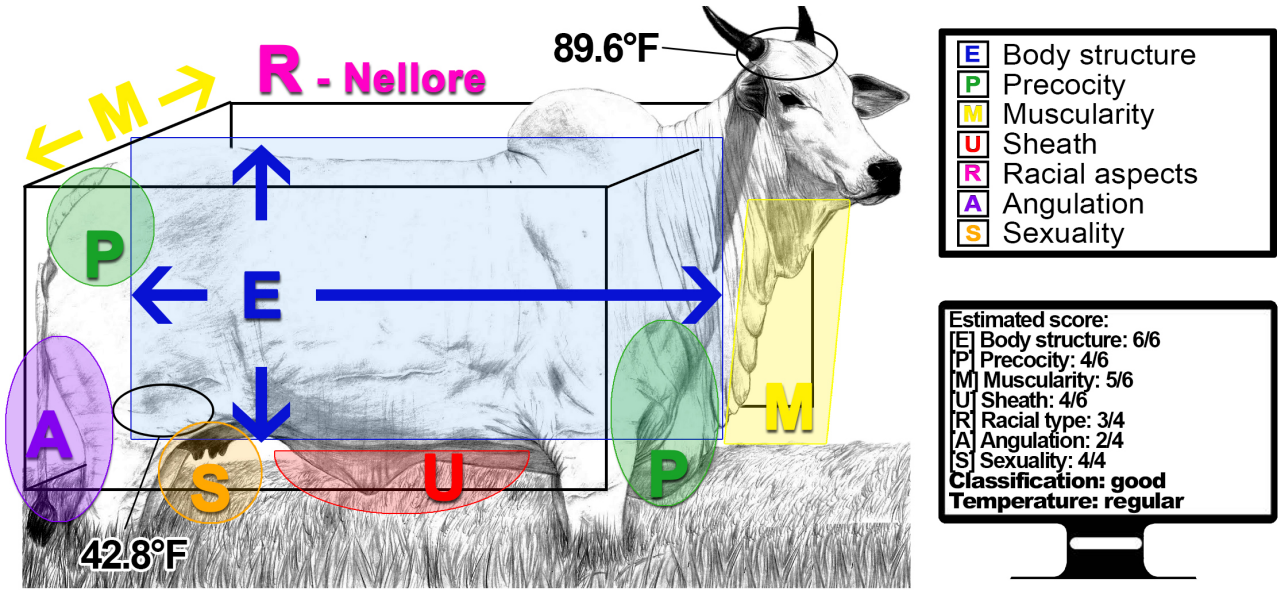

Fig. 1. The proposed system will indicate quantitative and qualitative information about cattle being analyzed by means of RGB-D-T information.

***Abstract*—Based on the analyses performed by experts, models have been created to assessing body condition of livestock. The goal is to identify parameters of quality that are perceived from identified visual features. Although human visual assessment is still the main way used to analyze morphological structures of livestock, it needs improvements in accuracy, agility and automation. Our work proposes the development of an automated system for automatic visual analysis of morphological features of live cattle by means of a fusion of RGB-D and thermal cameras. The goal is to rank the animals from their visual features in a qualitative and quantitative way. Since morphological features are associated with genetic improvement methods, the proposed system aims at recommending a balanced bio-type – suitable for breeding, abate and commercialization. The ultimate goal is to improve cattle productivity. This paper contextualizes the problem, proposing a generic framework for the automatic system.**

***Keywords*-Live Cattle; Visual Analysis; RGB-D-T Data.**

I. Introduction

Commonly, experts in visual analysis of cattle body structure measure features in live cattle by tactile and visual analyses. There are three main methods of evaluation by visual scores based on identification of body attributes, which are used to categorize the cattle: CPMU (conformation, precocity, muscularity and sheath), EPMURAS (body structure, precocity, muscling, sheath, racial features, angulation and sexuality) and MERCOS (muscularity, physical structure, racial aspects, conformation, sheath and aspects). Feature analysis of these methods are used to elect the best bio-type for breeding, commercialization, and reproduction. In words, the purpose of these metrics is to efficiently identify animals that meet the best animal biotype, under appropriate conditions of cattle growing, being in line with the consumer market [1].

Contributions: The main goal is to develop an automatic evaluation system of live cattle characteristics by means of an RGB-D-T-based image acquisition system (RGB-D and thermal information), quantitative and qualitatively classifying the animals from their visual attributes. Classification will be carried out based on existing visual scales. The following system characteristics are pursued:

- ensure greater accuracy and reliability in bovine body evaluation;
- identify and analyze the largest possible number of attributes in order to create automatic index selection;
- use the analysis of animal temperature to assist with the creation of indexes to evaluate its body condition.

Motivation: Visual methods for livestock evaluation, performed by humans, are used in several situations [2], such as: purchasing criteria and disposal of animals, provision of genealogical records by technical associations from different breeds, comparative trials on the slopes of agricultural show, mating, and phenotype performance and genetic evaluation when existing. As the evaluation of cattle characteristics is in great part obtained by the visual inspection of a specialist, being mostly prone to subjectivity, the assistance of a Computer Vision-based system might result in a more accurate and agile cattle selection, and hereby more productivity.

The use of thermal data can be of underlying importance for the analysis of the milk and cattle body condition, possibly indicating a muscle problem or any type of infection [3]. With shape (RGB-D) and thermal information, reconstructed in a 3D-thermal volume by using Computer Vision and Machine Learning techniques, it is possible to increase the data volume to be analyzed, and consequently the precision of the diagnostic of cattle state. Due to the great number of gathered data, deep learning techniques along with probabilistic methods is an eligible starting point to extract visual features from the RGB-D-T data, and to provide the qualitative and quantitative outcomes.

The essential way to improve livestock productivity is by reducing the period of cattle in farms. This may occur after the improvement of zoo technical indexes for meat production in less time and cost [4], and that is our goal with the proposed system.

A. Related work

To the best of our knowledge, although there are existing systems that use thermal information to evaluate cattle temperature condition [5], there is no other system that automatically assist a specialist in taking decisions about cattle body condition by means of Computer Vision and Machine Learning techniques, using features of EPMURAS method (Body structure, precocity, muscularity, sheath, racial aspects, sexuality). The choice of EPMURAS method was due to the completion of existing features in the method, which includes the main features necessary for selection of quality cattle, as will be shown in Section II.

B. Technique overview

An illustration of system registration of a cow is depicted in Fig. 1, which shows the parameters commonly analyzed by the following visual scores: E – conformation of the cattle in terms of body structure; P – deposition of subcutaneous fat; M – the amount of muscle contained in the animal; U – a measure of sheath shape; R – animal breed type; A – arching the lower and hind limbs; S – sexuality of the animal; and finally the temperature measured close to the teats and head. On the right, an image caption describes an example of qualitative and quantitative evaluated characteristics of the cow.

These parameters are based on EPMURAS scale, having a range of scores for each of the following features: E – Body structure; P – Precocity; M – Muscularity; U – Sheath; R – Racial aspects; A – Angulation; and S – Sexuality. The scores are classified from 1 to 6 for E-P-M-U features, where 1 is the lowest score and 6 is the highest one. Conceptually each score presents the representation as follows: 1 – Weak; 2 – Regular; 3 – Good; 4 – Very good; 5 – Nice; and 6 – Excellent. The R-A-S scores are classified from 1 to 4, where 1 is the lowest, while 4 is the highest, meaning: 1 – Weak; 2 – Regular; 3 – Good; and 4 – Nice [1]. These scores are the basis for the development of a qualitative and quantitative system method. The features of EPMURAs method is specified completely in Section II-B.

II. Setup for data acquisition

A. Setup

We are building a multimodal system of cameras, comprised of an RGB-D camera and a FLIR A325s thermal camera (see Fig.2). Characteristics of the RGB-D camera are: 6.1mm of focal length, field of view (FOV) of $57^\circ \times 45^\circ$, image size of 640x480 pixels. Characteristics of the thermal camera are: spectral range of 7.5-13.0 in micrometer, image size of 320×240 pixels, frame Rate of 60Hz, focal length of 4.0mm, and FOV of $90^\circ \times 73^\circ$). The cameras are arranged so that their lenses are horizontally aligned, fixed by a metal base that keeps the setup stable, making it easy to capture images within the required field of view.

The software used for camera system connection are: ResearchIR (native FLIR software for images acquisition and display), MATLAB R2016a (high-performance development environment for numerical activities and software prototypes), and Kinect SDK 1.8. The multimodal system and the calibration method for the cameras capture the RGB-D-T images in order to map the areas which match. With that, it is possible

Fig. 2. Multimodal system of a thermal camera FLIR A325sc and an RGB-D camera Microsoft Kinect 360.

to make a 4D (3D + thermal information) reconstruction of the bovine being observed.

B. Body analysis by visual scores

The main methods for evaluation of visual scores of cattle are: EPMURAS, CPMU and MERCOS. These three methods are based in the number of attributes that are used as a parameter to perform the best selection of animal body biotype. CPMU methodology refers only to four body attributes, leaving aside important points like sexual characteristics [6]. It is also known that the MERCOS method is best used at time of weaning and yearling. To exploit a more complete set of attributes for bovine selection in different areas and focus on productivity for the consumer market, the method chosen for development of the system was EPMURAS, due to contemplation in identifying and analyzing the largest possible amount of attributes for creation of automatic indexes.

EPMURAS method is used by the Brazilian Association of Zebu Breeders (ABCZ) [7]. It was created by the redefinition and inclusion of bovine features already identified over time, having the main goal of identifying animals' better body biotype for the consumer market. EPMURAS method consists in seven attributes, as described by ABCZ (2003) [7] and Koury Filho's methodology (2005) [2]:

- Body structure: visually prediction of the animal surface, seen from the side by observing the body compliance and the depth of the ribs. The area that encompasses the animal is connected to its limits in muscle tissue deposition, graded by a scale from 1 to 6, considering 1 to the lower structure and 6 to the larger structure.
- Precocity: evaluates the early biotype, held from the deposition of subcutaneous fat, seeking for animal best rib depth ratios for the members. In younger ages, where often the animals does not exhibit fat cover, the goal is to identify the design which corresponds to cattle that will present fatness earlier, typically representing animals who have more ribs over the height of their members. Subcutaneous fat deposition indicates the evaluation of an early type, such as: muscles, groin or lower heavy points as tail set, brisket, shoulder and spine [8].
- Muscularity: evaluates basically evidence of muscle mass distributed in the animal.
- Sheath: it is measured from the reference size and positioning of the umbilicus, sheath and prepuce. The note 1 reveals a more pendulous sheath, and note 6 to a lower belly buttons and hems, excluding animals with foreskin prolapse.
- Racial features: the racial type is a strong commercial differential and has a great market value, due for attributes set out in the racial patterns of the respective zebu breeds (in this case Nellore). It should be considered in the visual evaluation.
- Angulation: animals are evaluated according to directions, proportions, angles and articulations of the front and hind limbs. This feature is directly referred to animal reproduction and time, remaining in the herd.
- Sexuality: features of masculinity and femininity in males and females respectively. For example, in Nellore race, there is a type of ox with face bevel, short and stout, wrinkled eyes and obvious leak, and a cow with lighter and delicate head, pleating udder and vaginal development according to age. The greater the age of these animals, the more pronounced this feature should be.
  It will be up to the camera system to raise and to evaluate the aforementioned parameters, as well as, to define the cattle selection of scores with better body biotype.

C. Calibration of the cameras

Camera calibration process is widely discussed in the literature, as can be seen in [9], [10], [11], [12], [13]. Calibration can be monocular, made from a single camera, or stereo, made by two or more cameras. In this project we use stereo mode, estimating intrinsic and extrinsic parameters suitable for the definition of 3D transformations for 2D or homographies from one camera to the other. The intrinsic parameters refer to characteristic data from each camera: scale factors and projection of the optical center. The extrinsic parameters are related to camera interaction with the external environment, basically referring to rotation and translation matrices. Cameras of different types may have different FOVs, and the calibration of these cameras aims to get the same point in a given area, from a geometric model [3]. In this work, a calibration method based on the works of Zhang (2002) and Rangel *et al.* (2014) is being reproduced. For that, the use of a flat calibration object with detectable markers in a standard manner is required. Once the calibration pattern is detected in the images, a calibration algorithm is applied, relating image coordinates and the spatial coordinates of the detected markers on the target.

III. Proposed framework

The goal of this project is to develop an automatic detection method to obtain the EPMURAS parameters from bovine image morphological features. An image of the proposed framework is depicted in Fig. 3. Next, the main steps of the proposed framework are described:

1) A camera calibration process in order to build a 3D model from the information acquired by the RGB-D and thermal cameras;
2) Image pre-processing and filtering to adjust brightness, reduce noises, among other improvements;
3) Normalization to correct tridimensional proportions of the model on focus;
4) 4D reconstruction with stitching techniques to acquire the virtual 3D shape of the animal to be evaluated and temperature analysis for health of cattle;
5) Adequate segmentation of the main functional parts of the animal;
6) Feature extraction and shape analysis for find anatomic extract points and looking at it from different angles, considering different properties of the animal.

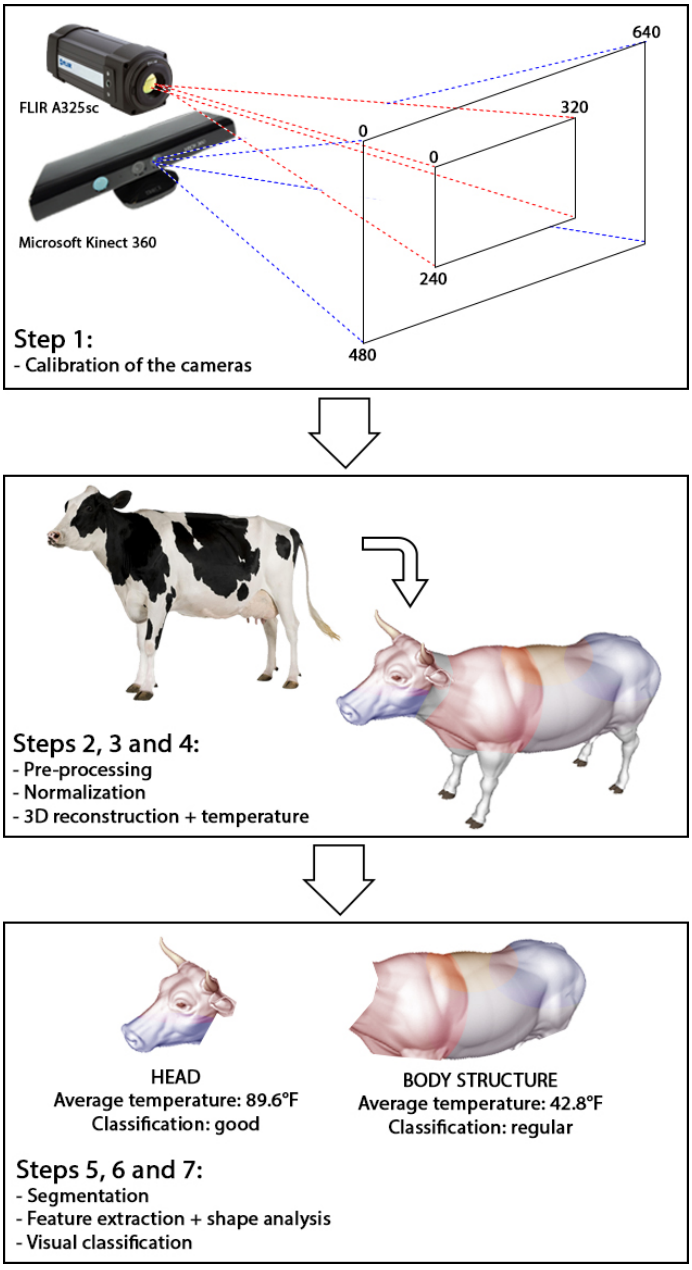

Fig. 3. Proposed framework. From the calibration of the cameras until the final analysis of a bovine.

7) Comparison of the model built with templates with size and temperature indexes previously labeled, by using methods, such as Procrustes analysis and deep learning.

In addition to these steps, the following methodological activities are proposed:

1) Calibration of the cameras: define a set of equipment and techniques to calibrating RGB-D and thermal cameras;
2) Acquisition of dataset: perform the acquisition of images to build the data set of bovines;
3) Analysis of data sets: Image analysis by means the techniques of pre-processing and segmentation.
4) Implementation of the method: Implementation of the method for detection and extraction of bovine features, based in EPMURAS parameters;
5) Validation: validate the automatic selection method of cattle built on the EPMURAS parameters, with animal husbandry experts.

IV. Conclusion

To the best of our knowledge, there is not a system with this proposed goal, so far. The visual evaluation can be performed with greater objectivity, accuracy and agility, promoting improvements in the quality of bovine selection based on morphological features. It is also expected a national impact, with increasing category of livestock productivity and economic growth. Industries may use the autonomous system to evaluate more effectively the cattle. In addition to the creation of an evaluation method for bovine Nellore cattle, it is believed that this evaluation system can include other races of distinctive characteristics found in Brazil, such as Angus and Brahman.

Acknowledgment

References

[1] L. A. Josahkian, C. H. C. Machado, and W. K. Filho, "Programa de melhoramento genético das raças zebuínas," p. 96, 2003.
[2] W. K. Filho, "Escores visuais e suas relações com características de crescimento em bovinos de corte," 2005.
[3] J. Rangel, S. Soldan, and A. Kroll, "3d thermal imaging: Fusion of thermography and depth cameras," *Conference on Quantitative InfraRed Thermography*, 2014.
[4] C. U. de Faria, M. C. Ulha, D. Albuquerque, L. G. aao, A. D. Los, B. Reyes, L. A. Framartino, and R. B. Lobo, "Análise genética de escores de avaliação visual de bovinos com modelos bayesianos de limiar e linear," *Pesquisa Agropecuária Brasileira*, vol. 43, no. 7, pp. 835–841, 2008.
[5] H. J. Hellebrand, U. Brehme, H. Beuche, U. Stollberg, and H. Jacobs, "Application of thermal imaging for cattle management," *1st European Conference on Precision Livestock Farming*, pp. 2–3, 2003.
[6] C. U. de Faria, C. de Ulhôa Magnabosco, L. G. ao de Albuquerque, A. de los Reyes, M. G. Saueressig, and R. B. Lbo, "Utilização de escores visuais de características morfológicas de bovinos nelore como ferramenta para melhoramento gentico animal," vol. 177, p. 40, 2007.
[7] ABCZ, "Programa de melhoramento genético das raças zebuínas," vol. 2, pp. 1–98, 2003.
[8] R. A. T. de Melo and M. M. S. C. Moura, "Avaliação visual em programas de melhoramento genético," vol. 2, pp. 2–6, 2013.
[9] J. Bouguet. (2015) Matlab calibration tool. [Online]. Available: www.vision.caltech.edu/bouguetj/calib_doc/
[10] Z. Zhang, "A flexible new technique for camera calibration (technical report)," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 22, no. 11, pp. 1330–1334, 2002.
[11] J. T. Lussier and S. Thrun, "Automatic calibration of rgbd and thermal cameras," *IEEE International Conference on Intelligent Robots and Systems*, no. Iros, pp. 451–458, 2014.
[12] N. Kim, Y. Choi, S. Hwang, K. Park, J. S. Y. Kweon, and I. So, "Geometrical calibration of multispectral calibration," no. Urai, pp. 384–385, 2015.
[13] A. Ellmauthaler, E. A. B. Silva, C. L. Pagliari, J. N. Gois, and S. R. Neves, "A novel interative calibration approach for thermal infrared cameras," pp. 2182–2186, 2013.