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LSSA_CAU: An interactive 3d point clouds analysis software for body measurement of livestock with similar forms of cows or pigs

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ABSTRACT

As increasing number of studies for shape measurement purposes in livestock farming by using consumer depth cameras, many software have been developed in order to measure livestock conformation. However, many of these softwares were designed only for specific livestock or body part of specific livestock with very limited body measurements. To be more flexible and general compared to the current software provided in the literature, an interactive software LSSA_CAU is developed to estimate body measurements of livestock based on 3d point clouds data. Livestock with similar forms of cows or pigs and standing with her head forward is assumed for designing algorithm used in LSSA_CAU. This software provides a set of tools for loading, rendering, segmenting, pose normalizing, measuring point clouds data of whole body surface of livestock in a semiautomatic manner. In order to validate the software, both synthetic and real world point clouds data of livestock were processed by using the LSSA_CAU. Our experiments show that the proposed software generalizes well across livestock species and supports customized body measurements. An updated LSSA_CAU version can be downloaded freely from https://github.com/LiveStockShapeAnalysis to livestock industry and research.

1. Introduction

The possibility of frequently monitoring animals body condition in a quantitative way is of help in order to allow early recognition of health anomalies and accordingly reduce occurrence of problems connected to infertility, lameness or other diseases (Roche et al., 2009). In the case of young cattle, the first months are fundamental since animal growth can be reduced by occurrence of different diseases or other stressing factors. Similarly in the case of adult cows or other livestock species, the measurement of body condition and development is relevant in order to monitor their welfare, and thus keep high productivity levels (Azzaro et al., 2011; Doeschl et al., 2004; Topal and Macit, 2004). In the last fifty years, live body weight or body measurements have been the most straightforward way to measure individual animals body development. However, manual body measurement are time consuming and costly for farmers. On the other hand, high levels of stress can be induced by manual measurements, especially in the case of younger livestock. Additionally, such techniques may injure livestock farmers.

To overcome the limitations of conventional measurement system, machine vision has been used extensively as a non-intrusive approach for animal body measurement (Kuzuhara et al., 2015). Several researchers assessed the feasibility of utilizing video and digital images to determine body shape, condition, and weight in dairy cows (Tasdemir et al., 2011; Azzaro et al., 2011), pigs (Brandl and Jorgensen, 1996; Marchant et al., 1999; Wongsriworaphon et al., 2015), sheep (Yilmaz et al., 2013; Menesatti et al., 2014), horse (Pallottino et al., 2015), broilers (Mortensen et al., 2016) and fish (Saberioon et al., 2016). The use of imaging or vision systems to predict or measure livestock development has been presented in several papers during last 30 years. Vision systems based on visible light is often affected by variation in ambient lighting, and must be calibrated accordingly. Subtraction of background is often a difficult task due to differences in animal color, complex scene in flexible living conditions. To overcome these drawbacks of using a standard camera for assessing body shape, researchers have examined the use of other imaging system such as ultrasound (Duff et al., 2010) and thermal cameras (Halachmi et al., 2013). 2-D images only offer two dimensional projection of the animal. The lack of the third dimension in vision limits applications utilizing depth information (Stajnko et al., 2008). Photogrammetry stereo techniques have been introduced to measure farm animals in three dimensions (3-D). One such suc-

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cessful example is a stereo vision system with six 2-D cameras and three flash units used to capture the 3-D shapes of pigs (Wu et al., 2004). However, these photogrammetric systems are difficult to implement. Novel 3-D systems can solve the problems posed by conventional 2-D vision systems, including photogrammetry stereo techniques. As a result, there has been increasing demand for these techniques in livestock farming (Weber et al., 2014).

Recently, consumer depth sensor based on a structured infrared-light (IR) system, such as the Microsoft Kinect or the ASUS's Xtion Pro, provide 3D data at low cost and has opened new possibilities for acquiring information of livestock conformation (Guo et al., 2013; Kawasue et al., 2013; Viazzi et al., 2014). The feasibility of using 3D camera imaging to estimate (body condition scoring) BCS for cow had been addressed (Viazzi et al., 2014; Weber et al., 2014). Weber et al. implemented the software for recording 3-D images from TOF camera (SwissRan-ger SR4000, MesaImaging, Switzerland), taken several cuts along aligned pose of cow through a cow's surface in order to calculate traits that are meaningful to the surface's changes induced by varying body condition during lactation (Weber et al., 2014). But they only focused on the animals' rear part. A calibrated 3D reconstruction system for cattle using three Kinect sensors was introduced, the important traits for evaluating the shape and posture of the cow were estimated using the point cloud data (Kawasue et al., 2013). Based on commercial software Artec Studio 9.2, the capacity for using back posture measurements of dairy cows with Xtion Pro Live to predict BCS and body weight (BW) as well as milking traits such as MY, milk fat (MF), and milk protein (MP) concentrations was evaluated (Kuzuhara et al., 2015). The major difference of this study is that they manually measured geodesic distance on six selected body regions so as to obtain body condition measurements. As increasing number of studies for shape measurement purposes in livestock farming, many software have been developed in order to acquire 3D surface data of livestock (Kawasue et al., 2013; Weber et al., 2014; Guo et al., 2014), to measure livestock conformation (Weber et al., 2014) or to estimate the livestock weight (Wongsriworaphon et al., 2015; Yilmaz et al., 2013). However, many of these softwares were designed only for specific livestock or part of specific livestock body. The most of existing point clouds software for reverse engineering or survey service, such as Geomagic and VRMesh (List of programs for point cloud processing, 2014), are capable of measuring, however, if you are measuring livestock point clouds it will need complex user interaction to align, measure livestock.

In view of the above, the main objective of this study was to develop flexible and general software named LSSA_CAU for analysis of livestock 3d point clouds, in order to estimate morphometric traits or body measurements defined by user in commercially interesting livestock species: cows, pigs, other livestock with similar form with those two species such as horses; and to validate this software by analyzing both synthetic and real world livestock point clouds acquired by using multiple depth cameras system (Guo et al., 2014) which we designed before. The targeted users of the LSSA_CAU software are livestock breeders, livestock farmers. In addition, LSSA_CAU can be used to enable lecturers, students and researchers in the fields related with livestock to explore and illustrate the relationship between livestock morphometric traits with other kinds of traits.

2. Materials and methods

2.1. Livestock 3D data requirements

In order to design the algorithms and implement the software, we aim to make some assumptions about the input 3D data of software in this section. Livestock body measurements require the scanning of rather complex three-dimensional animals to incorporate them into our computer-aided processing. There are three types of techniques, existing in the literature so far, which are able to digitize livestock's surfaces, namely photogrammetric stereo imaging system (Wu et al., 2004; McFarlane et al., 2005), time of flight depth cameras (TOF) (Salau et al., 2014) and consumer depth cameras like Kinect (Kawasue et al., 2013). They all can easily produce a large amount of points lying on the livestock's surfaces. Such a point set representing the surface of livestock we call a point cloud. Thus, let's start from a point cloud denoted by $S = \{p_i\}$, each point p_i has color or not and no other information. Without loss of generality, we assume that the input point clouds S mainly consist of one livestock standing on a planar ground plane with possible parts of other livestock facilities. Additionally, we make the following two assumptions about the livestock to be measured.

(1) A livestock has similar forms of cows or pigs which have small head in relation to their body size, long body with four legs, shorter hair.
(2) A livestock stand on the horizontal ground plane with her head forward. That is to say, the skeleton of pig top view is almost a straight line.

The first assumption is a requirement of the livestock shape that restrict our software and algorithms within specified range of application. The second one is an assumption of the pose of livestock that simplifies the pose normalization in the subsequent section. So are the assumptions of the composition of the input point clouds S. Fig. 2 shows the example of qualified input point cloud acquired by using our prototype system (Fig. 1) for animal 3D reconstruction (Guo et al., 2014). Multi-view 3D acquisition is out of scope of this research paper and is not a trivial task. We recommend readers refer to our paper about 3D scanning of pig (Guo et al., 2014), another research about 3D scanning of cows (Kawasue et al., 2013) and general multi-view real time 3D acquisition technique (Shim et al., 2012). Note that we have to keep the other livestock away from the one we are going to measure in practice. Thus we can guarantee that the point clouds acquired comply with the assumption that S only contains one livestock. Meanwhile we manually choose the frames which meet our requirements, since the output of our scanning system is point clouds sequences.

Fig. 1. Our prototype system (Guo et al., 2014) used for acquiring point clouds in this research.