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A Review of Morphometric Measurements Techniques on Animals Using Digital Image Processing

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Abstract. The existence of livestock, especially beef cattle in Indonesia, has enormous potential. In 2018, the population of beef cattle in Indonesia reached 16,432,945 heads. This population continues to increase in 2019 to 17,118,650 individuals. The increase in livestock productivity can be assessed from the dimensions of the body of the livestock by measuring directly using measuring instruments. This technique is called morphometrics. Morphometrics is a quantitative analysis technique (body dimensions) that includes shape and size. Morphometric data is an important parameter used to study livestock anatomy, productivity, growth rate, and performance quality of livestock. Manual measurements can provide several obstacles, including causing livestock to be stressed more easily, measurements become less accurate because cattle move too much and can even pose a risk of livestock aggressiveness that causes people to be injured by livestock attacks. This review article aims to summarize the literature related to morphometric techniques in animals in terms of the measurement approach used and the objects measured. Writing review articles are done by summarizing and analyze the morphometric measurement process approach technique. The articles studied were obtained by searching in international and national journals at Springer, ScienceDirect, IEEE, etc. The search was carried out with the keywords "Morphometrics", "Morphometrics", "Zoometric", and "Digital Image Analysis". The conclusion drawn from the review is that there are still many things that can be developed in this morphometric measurement technique. The key to the success of developing this morphometric technique method is that the more effective and efficient the measurement technique is, the better the results will be obtained. The final result expected in the future is to be able to create a morphometric approach technique that can be used in all fields and animals. Able to produce accurate and efficient morphometric measurements.

Keywords: *Animals*, *Morphometrics, Zoometric, Digital Image Analysis*

1. Introduction

The existence of livestock, especially beef cattle in Indonesia, has enormous potential. In 2018, the population of beef cattle in Indonesia reached 16,432,945 heads. This population continues to increase in 2019 to 17,118,650 individuals [1]. The Ministry of Agriculture through the Directorate General of

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Animal Husbandry and Animal Health noted that the national cattle population continues to increase. It was recorded that the birth of cows during 2019 reached 1,907,455 heads or exceeded the target of 1,680,000 heads, meaning that the number of cattle population increased by 113.54% [2]. This is in line with the vision of the Minister of Agriculture for Indonesia to become a world food barn by 2045 [3]. The role of livestock, especially beef cattle, is very important to note. Beef cattle are used as a provider of meat to meet food needs. One of the efforts to increase the productivity of beef cattle is by collecting quantitative data (body dimensions) of the cattle. Quantitative data are needed to identify and predict opportunities for increasing livestock productivity.

The increase in livestock productivity can be assessed from the dimensions of the body of the livestock by measuring directly using measuring instruments. This technique is called morphometrics. Morphometrics is a quantitative analysis technique (body dimensions) that includes shape and size. Morphometric data is an important parameter used to study livestock anatomy, productivity, growth rate, and performance quality of livestock. Conventional morphometric measurements are carried out by directly measuring livestock body parameters using a ruler, measuring stick, measuring tape regarding the bony prominence (tuberosity or processus) starting from height, body length, chest circumference, hip height, and so on [4]. The bone protrusion reference can also be used to determine the condition value of the livestock [5].

Manual measurements can provide several obstacles, including causing livestock to be stressed more easily, measurements become less accurate because cattle move too much and can even pose a risk of livestock aggressiveness that causes people to be injured by livestock attacks. [6]. Based on these constraints, many researchers have developed an easier method of measuring livestock morphometrics to reduce the risk of livestock stress during measurement and minimize the risk of livestock attack on the person measuring. This method is expected to be applied for safer morphometric measurements, produce more accurate data, and livestock that can be measured at the same time and can provide more data that cannot be taken in direct measurements [7].

2. Methodology

This review article aims to summarize the literature related to morphometric techniques in animals in terms of the measurement approach used and the objects measured. Writing review articles are done by summarizing and analyze the morphometric measurement process approach technique. The articles studied were obtained by searching in international and national journals at Springer, ScienceDirect, IEEE, etc. The search was carried out with the keywords "Morphometrics", "Morphometrics", "Zoometric", and "Digital Image Analysis". Most of the articles obtained are the results of research on the implementation of measurement techniques in animals using the morphometric approach. Articles that match the theme of the review are then reviewed by paraphrasing the core and common thread of the research. The following describes the details of the articles that have been reviewed and paraphrased.

Table 1. Details of the search method results for articles with specific keywords.

No.	Keywords	Total	Reference
1.	Morphometrics	8	[4] [8] [9] [10] [11] [12] [13] [14]
2.	Morfometrik	2	[6] [15]
3.	Zoometric	1	[16]
4.	Digital Image Analysis	12	[5] [7] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26]

3. Results and Discussion

Over the past two decades, the use of image analysis techniques as an alternative to measurements collected in direct contact with animals has increased. This technique allows more accurate measurements in shorter turnaround times and allows the storage of photo data to allow for subsequent

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consultation and verification, ultimately increasing the reliability of zoometrics. This measurement technique has the great advantage not only of an operational and an economic point of view but also of minimizing the stress on the animal when handled and measured. [17] [18] [7] [6] [15] [19] [8] [9]. Various image analysis methodologies for measuring morphometrics / zoometrics can be classified into two-dimensional (2D) and three-dimensional (3D) techniques. With 2D technique, an image is used to measure distances and angles after the appropriate scale factors are applied [6] [15] [18] [20]. With the 3D photogrammetric technique, several images are used simultaneously to recreate 3D information from the image. With this spatial information, beyond basic angular or distance measurements, photogrammetry allows a detailed study of the surfaces and shapes of various animal parts [21] [9] [8].

3.1. Two-dimensional (2D) measurement technique

In 2D image analysis, the accuracy and accuracy of the measurements depend on the image resolution, the accuracy of the distance measurement from the camera to the animal, and the orientation of the animal to the camera. A number of zoometric studies have been successfully carried out with 2-D image analysis of domestic animals, including pigs [22], rabbits [20], chickens [23] [24], cattle [6] [15] [5] [25], horses [9] [10] and buffalo [15] [19] [26]. One of the requirements of this 2D technology is that the morphometric/zoometric variables to be measured must remain perpendicular to the optical axis. In practice, this requirement limits the performance of many measurements in non-domestic animals. An example of a two-dimensional measurement technique in Ongole and Bali cattle. The parameters observed were macro parameters, namely in the chest, height, and body length. Measurement analysis is performed using the Image J application program by opening the digital image file to be measured. The next step is to determine the scale calibration by drawing a line on the measuring stick. Measurements can be made after calibration. Data analysis was performed using student's test hypothesis testing. The test results show that the body morphometric measurements between the manual method and digital image analysis do not show a significant difference, so it can be concluded that the digital image method on body measurements can be done and has the same value as manual measurement. [6].

3.2. Three-dimensional (3D) measurement technique

In 3D image analysis techniques, the use of a camera does not need to be oriented perfectly perpendicular to the morphometric/zoometric variables. So that it is possible to have more freedom in taking pictures of animal objects. However, the animal must remain in the same position while all pictures are taken from different viewpoints, and a minimum of two pictures using 2 cameras is required. With 3D image analysis, several zoometrics have been performed, including measurements of domestic and wild animals. As in the baleen rack 3D measurement model of the whale [11] obtained without incapacitating the animal. However, this measurement has the drawback of limited accuracy due to the inevitable movement of animals [12]. So that if you want good accuracy, the animal must not move or use more than 2 synchronized cameras. In several studies, animal immobilization has been performed under anesthesia on seals [13] and sea lions [14] to be able to estimate animal body weight. However, the use of anesthesia does not appear to be a suitable solution because of the costs and limitations of taking certain measurements on lying animals. Therefore a measurement technique was developed using several cameras to measure livestock using a 2D-image approach taken portally with a synchronized camera without anesthesia treatment on livestock [16].

3.3. Challenges in Developing Real-time Morphometric Measurement Techniques

More than 25 years of research has been developed on the technique of measuring livestock and wild animals using the morphometric approach. Many of these approaches have been developed starting from manual techniques with the risk of increasing the stress level of the animal causing the measuring party to become injured. Then an anesthesia technique was carried out to overcome this problem until the development of a two-dimensional (2D) measurement technique by capturing an image of the animal object using a digital camera with the measurement process done with digital computing [6]. However,

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this 2D technique has a drawback, namely the limited morphometric measurement process because the camera cannot reach the desired point in the morphometric process and it seems that it takes a long time to process the morphometric measurement results.

Based on these shortcomings, a three-dimensional (3D) measurement technique was developed. the measurement process is carried out using more than 2 cameras that are connected to each other with the placement of predetermined angles. This technical approach can overcome the shortcomings of the two-dimensional (2D) measurement approach. However, there are deficiencies in this 3D technique approach, namely that livestock objects are required to be in a fixed position to measure the desired point in the morphometric technique and need a special place to carry out the measurement process. This is because the 3D engineering approach requires measurable settings so that the animal measurement process cannot be carried out in the wild or non-portable situations. Therefore, the researchers formulated a new approach/technique to be able to overcome this problem, namely by developing a real-time morphometric measurement approach using a machine learning approach. It is hoped that this approach can solve the problems faced by previous researchers and be able to provide effective and efficient results.

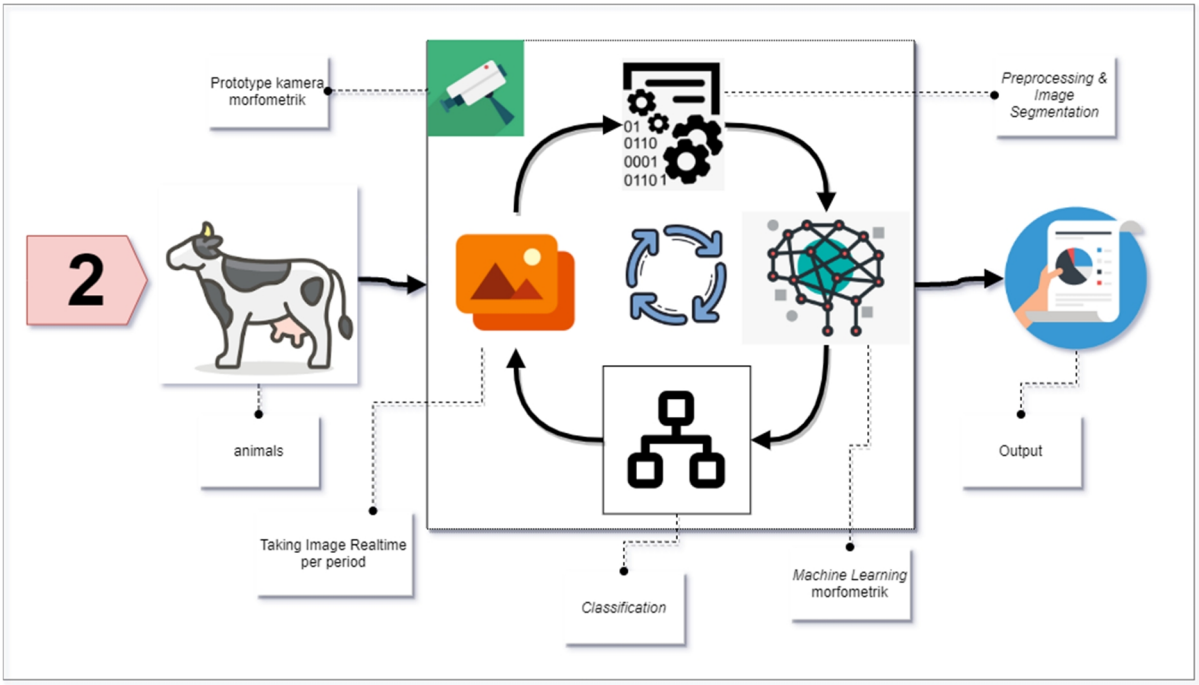

Figure 1. The Propose principles of development of real-time morphometric measurement techniques.

4. Conclusions

The approach to morphometric measurement techniques developed by many researchers with a large number of animal objects carried out to obtain information about animals, both livestock and wild animals, has resulted in significant progress. However, based on the literature review that researchers have done, there are still many things that can be developed in this morphometric measurement technique. The key to the success of developing this morphometric technique method is that the more effective and efficient the measurement technique is, the better the results will be obtained. The final result expected in the future is to be able to create a morphometric approach technique that can be used in all fields and animals. Able to produce accurate and efficient morphometric measurements.

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