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An automatic splitting method for the adhesive piglets' gray scale image based on the ellipse shape feature

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ABSTRACT

The average weight of piglets in lactation can be monitored automatically by piglets' average weight monitoring systems which are designed based on wireless multimedia sensor networks. Piglets counting in an automatic manner for piglets images is the foundation of these systems. Adhesive piglets may exist in an image due to the social character of piglets, which challenges the image splitting and automatic piglets counting.

This paper proposes a segmentation algorithm for adhesive piglets images based on ellipse fitting method. Firstly, ellipse fitting is implemented for a large number of images which have one piglet. Parameters range of ellipses fitted by images with a single piglet on different age is extracted. Secondly, contours of connected components in an adhesive piglets image are extracted. Each contour is segmented based on concave points. Ellipse fitting is implemented for each contour segment. Finally, 5 rules for ellipse merging are put forwarded, which are used to merge anomalous ellipses. After ellipse merging, the number of ellipses equals the number of piglets. The proposed algorithm is applied to adhesive piglets images in Matlab R2012b and the experimental results show that the counting accuracy exceeds 86% when the number of piglets is less than 7. The algorithm provides the foundation for the piglets' average weight monitoring systems.

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1 Introduction

In pig breeding area, the health and welfare of piglets and sows are of most important. The feeding, drinking, rest behavior and weight gain model are stable for healthy pigs (Madsen et al., 2005). At present, many animal behavior analyses are based on computer vision (Bin et al., 2008; Cangar et al., 2008; Lind et al., 2005; Viazzi et al., 2014). Individual animal locating, tracking and adhesive animal image segmentation are foundations of animal behavior analysis (Ahrendt et al., 2011; Kashiha et al., 2013).

Many automated methods for animal weight gain monitoring based on computer vision have been proposed in recent years too (Doeschl-Wilson et al., 2004; Menesatti et al., 2014; Mollah et al., 2010; Schofield et al., 1999; Tasdemir et al., 2011). Mollah et al., 2010 developed a linear equation to estimate the weight of a broiler from its body surface-area pixels. Tasdemir et al., 2011 obtained the coefficients of regression equations which can estimate the live weight of cows. Doeschl-Wilson et al., 2004 and Schofield et al., 1999 established a weight estimate model based on image acquisition systems for growing pigs.

But research is rare by far on automated weight gain monitoring for piglets in lactation. The daily weight gain of piglets in lactation not only reflects the milk yield and the performance of sows, but also affects the growth of pigs in fattening stage. At the same time, a sudden change of weight gain speed is an important index of healthy disorder of piglets.

Manual operation method has been used widely to monitor piglets' weight gain. Following this method, people put a piglet on a weighing platform and measure its weight. Unfortunately, a piglet moves frequently on this platform, which leads to errors of measurement. Furthermore, this method is time consuming. A remarkable difference between our method and the traditional method is that weighting of piglets can be done when they are at rest. So, our measurement is more accurate because there are no movements of piglets. We designed a prototype system which can monitor the

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weight gain of piglets based on the wireless multi-media sensor network (WMSN, Ian et al., 2007). The designed prototype system is named PWS-WMSN (Piglets' average Weight monitoring System based on WMSN).

The most important sensors used in PWS-WMSN are weighing sensor and CMOS image sensor. The former measures the total weight of piglets which are resting in an incubator, the later captures gray scale images of piglets. Total weight and images are transmitted to a computer and the number of piglets in an image is calculated automatically. Then the average piglets' weight can be obtained based on the total weight and the quantity of piglets. Due to the social character of piglets, adhesive piglets may exist in images. Automatic piglets counting for adhesive piglets' gray scale images challenges the realization of PWS-WMSN.

Research on the automatic segmentation for adhesive objects images in precision agriculture realm has been presented in some literature at present (Lin et al., 2014; Song et al., 2014; Xu et al., 2013; Pastrana et al., 2013). Song et al., 2014 presented a method for fruits recognizing and counting from color images of peppers; Xu et al., 2013 presented a method for strawberry detection which helps strawberry harvesting robots. The method, based on a histogram of oriented gradients descriptor associated with a support vector machine classifier, can appropriately handle images with slightly overlapping strawberries. Pastrana et al., 2013 presented a novel approach based on active shape models to solve the problem of plantlets recognition under overlapping situations.

The algorithms proposed in the work mentioned above can be divided into the following two categories: some of them are designed to split adhesive objects in color images, and some others can split adhesive objects with regular shapes (circle, for example) only. These algorithms could not be used to split adhesive piglets' gray scale image because the shape of a piglet is not regular and the color information is limited.

Under the condition that piglet's legs are neglected, the shape of a piglet at rest is similar to an ellipse (Kashiha et al., 2013). At the same time, the spatial relationship of piglets at rest can be divided into four kinds: (1) separating from each other, (2) touching but not overlapping, (3) slight overlapping, and (4) large overlapping, as shown in Fig. 1.

This paper proposes an adhesive piglets image splitting algorithm based on piglets' shape character and ellipse fitting. The proposed algorithm can accomplish piglets counting for gray scale images with separating piglets, touching but not overlapping piglets, or slightly overlapping piglets (Fig. 1a–c for example). Electric heating boards are widely used in incubators currently, which provide even heating. Under the condition that an incubator is not crowded, the probability of large overlapping (Fig. 1d) is very low. So the proposed algorithm in this manuscript does not consider images with large overlapping piglets.

2 Materials and methods

2.1. Architecture of PWS-WMSN prototype system

The architecture of PWS-WMSN prototype system is shown in Fig. 2.

PWS-WMSN, deployed in sow farrowing houses, consists of average weight data collecting nodes (AWDC nodes), gateway nodes, and a server. Every farrowing house has a gateway node and every incubator is equipped with an AWDC node. An AWDC node collects the total weight and an image of piglets in the

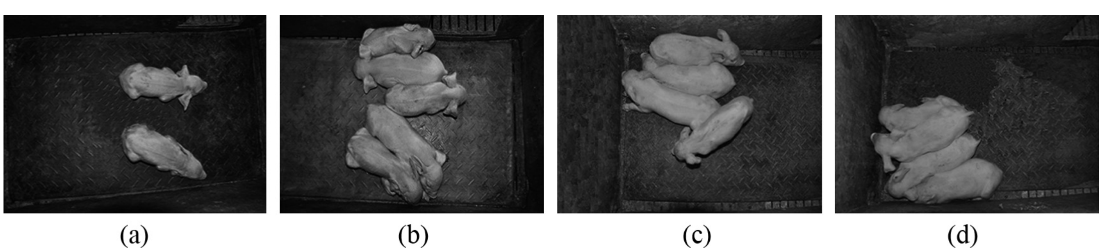

Fig. 1. Spatial relationship of piglets at rest. (a) Piglets are separating from each other; (b) piglets are touching but not overlapping; (c) piglets are slight overlapping; and (d) piglets are large overlapping.

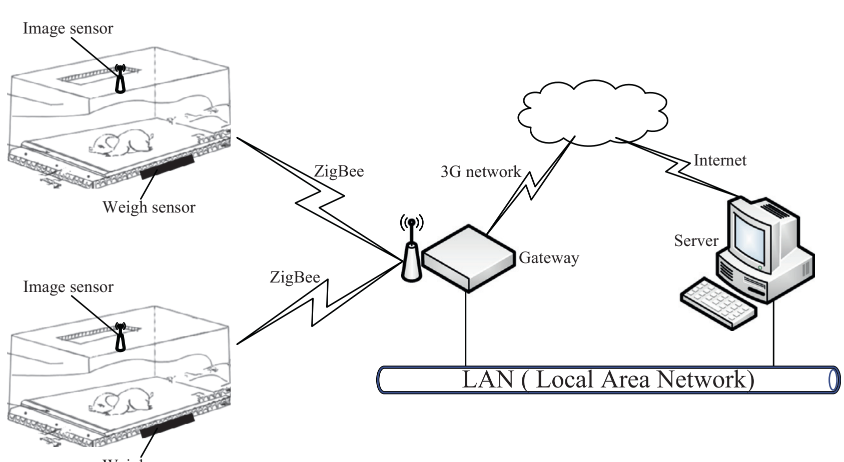

Fig. 2. Architecture of the prototype system for piglets' average weight monitoring.

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