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Research Paper

Identification of group-housed pigs based on Gabor and Local Binary Pattern features

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A novel method for the identification of group-housed pigs based on machine vision is proposed. It benefits to the automatic detection and analysis of the behaviour of pigs. Top-view videos of pigs were obtained and the images of individual pigs extracted. The Gabor features were extracted by convolving pig images with Gabor filters and the local structural features using the Local Binary Pattern (LBP) identification. Principle Component Analysis (PCA) was then used to reduce the feature dimension and the features were concatenated to form the feature vectors. In order to evaluate the performance of the proposed method, standing posture images of pigs were used to conduct the experiments in terms of Support Vector Machine (SVM) classification. The experimental results demonstrated that the combination of Gabor and LBP features produced better results. The average recognition rate achieved 91.86% by SVM with a linear kernel and the PCA parameter varied from 0.85 to 0.99.

1. Introduction

With the growing number of large-scale livestock farms in China, individual identification of animals becomes more important since it benefits livestock behaviour recognition. For pig identification, the Radio Frequency Identification (RFID) technology has been widely used (Maselyne, Saeys, & Nuffel, 2015; Voulodimos, Patrikakis, Sideridis, Ntafis, & Xylouri, 2010; Ma, Wang, & Ying, 2011). However, it requires additional hardware and software (Maselyne et al., 2014). Each pig is fitted with an electronic ear tag which is intrusive and at least one set of card readers is required in an area. In addition, it is hard to identify each pig when more than one pig is within the range of a card reader at the same time. To solve this problem, a feed intake channel is normally used to ensure that only one pig can pass through at any one time. However, this causes additional limitations for pig identification.

Compared to the RFID, pig identification based on computer vision without the use of ear tags is non-invasive. Animal behaviour analysis based on computer vision is therefore

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Nomenclature

$G_{u,v}$	Gabor response
u	Gabor parameter of orientation
v	Gabor parameter of scale
I	input image
z	pixel intensity
$\Psi_{u,v}$	Gabor kernel function
$A_{u,v}$	Gabor magnitude response
$\theta_{u,v}$	Gabor phase response
I_c	grey value of middle pixel in a sub-block
I_k	grey value of pixel in the neighbourhood of I_c
f_l	LBP coding image
$H_{i,j}$	LBP histogram of sub-block
H	concatenated LBP histograms
α	random vector
W	transformation matrix
β	principal component of the random vector α
w_i	ith orientation of the random vector α
γ	Lagrange multiplier
b	bias
K	SVM kernel function

gradually replacing other methods (Lao, Teng, Li, Yu, & Li, 2012; Leroy et al., 2006; Xue & Henderson, 2006). For pig identification, Kashiha et al. (2013) marked the backs of pigs with different colours and shapes and then automatically identified ten pigs using image analysis. Zhu, Chen, and Guo (2014) presented a method for group-housed pigs identification in complex background. In this method, individual pigs were segmented in a region of interest. An image histogram, colour moments, a grey level co-occurrence matrix and shape features were then extracted. Local Linear Embedding (LLE) feature optimisation and the Support Vector Machine (SVM) models with hybrid kernel function were applied.

In real farming environments, imbalanced local illumination affects the feature extraction of colour and contour. Since texture features can describe the spatial distribution of neighbouring pixels in an image and they are insensitive to the variations of colour and illumination, methods based on using texture features are discussed in this paper. Considering that Gabor wavelet image features can be extracted over a broad range of scales while Local Binary Pattern (LBP) features can capture small details. Thus here we propose a novel method based on Gabor and LBP methods for the identification of group-housed pigs. Firstly, top-view videos of the group-housed pigs are captured and images of individual pigs extracted. The Gabor features are extracted using Gabor filters and the local structural features identified using LBP. Principle Component Analysis (PCA) is then used to reduce the feature dimension and finally the Gabor and LBP features are concatenated to form the feature vectors. To test the performance of the proposed method, standing posture images of pigs were used to conduct extensive experiments using different Gabor parameters, image groups, features and different SVM kernel functions.

2. Materials and methods

2.1. Image acquisition

Experimental videos were captured from the pig farm of the Danyang Rongxin Nongmu Development Company, based at Jiangsu University. The image acquisition system consisted of a camera located 3 m above the ground of a pigsty. The pigs were monitored by the camera of FL3-U3-88S2C-C from Point Grey Research Inc. (Riverside Way, V6W 1K7 Richmond, BC, Canada). RGB videos of the group-housed pigs in a sty were captured with resolution of 1760 × 1840 pixels, as shown in Fig. 1.

2.2. Image pre-processing

In order to avoid occlusions, top-view videos were used in the experiments. In image pre-processing, the videos of group-housed pigs were divided into image frames. Image frames without pig adhesion were employed in which pigs were not sticking together. An adaptive method (Guo, Zhu, Jiao, Ma, & Yang, 2015) was used to extract individual pigs, as shown in Fig. 2. Figure 2(a) is an image frame and Fig. 2(b) is the result of foreground detection. Figure 2(c) is the image of pig No. 3 extracted from Fig. 2(b). In order to obtain the original pig images for feature extraction, Fig. 2(c) was used as a template with Fig. 2(a). Then individual pigs were re-extracted based on their centroid and normalised to the same size. Figure 2(e) is the image of the individual pigs extracted from Fig. 2(a).

2.3. Feature extraction

From the image of individual pigs, different patterns on the surface of pig's body are obtained. Figure 3 gives some example local images of the backs of pigs. The shape of natural muscles, the direction of hairs and spots caused by colour changes all form the patterns on the skin surface. The patterns depend on genetic and environmental factors such as pig breed and the process of growth. Therefore, these patterns can be used as a powerful tool for pig identification.

Here texture features were used to describe these patterns. Texture can be decomposed into many repeated texels, which are arranged according to certain rules. The minimum texel is the pixels in the image. Local patterns and their arrangement rules, appearing repeatedly in the image, are described by texture features. Texture features reflect the rules of grey changes, which are very benefit to pig identification.

Although many algorithms can be used for texture feature extraction, none of them can be fully applied to all the situations. Consequently, using only one set of features to identify the group-housed pigs may be insufficient. Based on information fusion theory, a combination of different features extracted from pig images could make full use of their advantages and recognition error will decrease.

Gabor wavelet transform can simulate the response of simple cells of human visual cortexes accurately (Marčelja, 1980). It describes the texture information of pig images with