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Pig herd monitoring and undesirable tripping and stepping prevention

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ABSTRACT

Humane handling and slaughter of livestock are of major concern in modern societies. Monitoring animal wellbeing in slaughterhouses is critical in preventing unnecessary stress and physical damage to livestock, which can also affect the meat quality. The goal of this study is to monitor pig herds at the slaughterhouse and identify undesirable events such as pigs tripping or stepping on each other. In this paper, we monitor pig behavior in color videos recorded during unloading from transportation trucks. We monitor the movement of a pig herd where the pigs enter and leave a surveyed area. The method is based on optical flow, which is not well explored for monitoring all types of animals, but is the method of choice for human crowd monitoring. We recommend using modified angular histograms to summarize the optical flow vectors. We show that the classification rate based on support vector machines is 93% of all frames. The sensitivity of the model is 93.5% with 90% specificity and 6.5% false alarm rate. The radial lens distortion and camera position required for convenient surveillance make the recordings highly distorted. Therefore, we also propose a new approach to correct lens and foreshortening distortions by using moving reference points. The method can be applied real-time during the actual unloading operations of pigs. In addition, we present a method for identification of the causes leading to undesirable events, which currently only runs off-line. The comparative analysis of three drivers, which performed the unloading of the pigs from the trucks in the available datasets, indicates that the drivers perform significantly differently. Driver 1 has 2.95 times higher odds to have pigs tripping and stepping on each other than the two others, and Driver 2 has 1.11 times higher odds than Driver 3.

1. Introduction

Today most consumers are not interested in meat quality alone but also in the welfare of the animal (Verbeke and Viaene, 2000; Napolitano et al., 2010; Kehlbacher et al., 2012). Moreover, high levels of stress before slaughter can affect the meat quality (Warriss et al., 1994; Brandt et al., 2013). Bruises caused before slaughter can also impair the value of meat sold with skin. In this paper, the behavior of pigs in a large and automated slaughter house that can handle up to 62,000 pigs per week is analyzed. It is difficult to keep track of that many pigs and ensure that they remain stress-free during handling. To complicate matters further, pigs which are unfamiliar with each other (e.g. coming from different fattening) can potentially attack each other causing unnecessary stress and physical damage (Oczak et al., 2014). In this study, pigs are filmed upon arrival at the slaughter house during the unloading of a truck. During transportation, pigs are usually sedentary therefore they often move slowly during unloading. To speed up the process, truck drivers are allowed to use specially designed sticks with sound effects. Pigs often react differently and some start moving too fast, resulting in a stampede. Consequently, they can start tripping and may step on each other. This situation can increase the stress level and may cause injuries (Broom, 2005). Most of the undesired situations, such as pigs tripping or stepping on each other, happen when animals are moving too fast and densely confined in an area. Consequently, we want a process where they move as fast as possible while ensuring that the animals remain stress-free and unharmed. The aim of this paper is to monitor pig herds at the slaughterhouse and determine when pigs stampede or about to stampede and give notice to the personnel to slow down the unloading and avoid events where pigs are tripping or stepping on each other. In our previous work, we proposed monitoring pig herd movement based on video surveillance without identifying individual animals (Gronskyte et al., 2015). Previous studies by Ahrendt et al. (2011) and Kashiha et al. (2013) tracked several individual pigs in a constrained area,

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which means that all pigs at all time were visible, whereas we analyzed the herd movement in an "unconstrained" area, allowing for pigs to enter and then leave the surveyed area.

The videos provided for this analysis were recorded at an angle with radial lens distortion. As a result of lens and foreshortening distortions, some additional steps had to be taken before the final behavior could be classified. Optical Flow (OF) was used to monitor the pig herd movement. Initially OF is estimated for an entire frame, thus pigs are identified and OF is filtered to only analyze movement of the pigs. Due to the special trot of pigs, averages of OF vectors are not suitable for behavior monitoring (Gronskyte et al., 2015) as proposed by Dawkins et al. (2009, 2012). Instead, we propose in Gronskyte et al. (2015) monitoring discriminant herd movement features extracted from a modified angular histogram (MAH) (Gronskyte et al., 2015) using Support Vector Machines (SVM) (Hastie et al., 2009, pp. 417–458). A MAH of a single frame describes the distribution of the OF vectors' median lengths over the entire angle range. The analysis based on MAH can be used in cases where monitored objects present a specific walking pattern. The overview of the described approach is presented as a flowchart in Fig. 1. The results of the SVM can also be studied on the basis of several frames, rather than a single frame. In this context, we will describe the possibilities of identifying the causes of the stampede.

In the following section a brief literature review on behavior monitoring is presented. In Section 2 the data are presented. The method is presented in Section 3 followed by the summary of the results given in Section 5 and the conclusion in Section 6.

1.1. Literature review

There is extensive research carried out on behavior monitoring of humans, and farm, wild and laboratory animals. There have primarily been two approaches to human behavior monitoring: tracking individuals or using OF. An overview of the human behavior

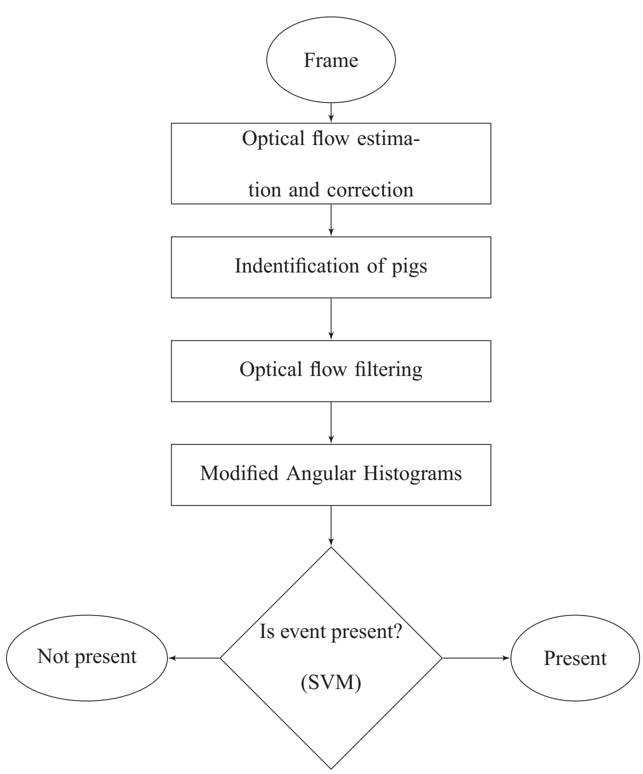

Fig. 1. Flowchart of the proposed pig behavior monitoring approach.

monitoring methods is given in Hu et al. (2004). Some of the methods focus on detecting a single action, like a snatch, in surveillance videos (Ibrahim et al., 2010) or dense crowds trying to use escalators (Ihaddadene and Djeraba, 2008). A large number of methods focus on detecting any abnormality in the videos (Mehran et al., 2009; Kratz and Nishino, 2009; Boiman and Irani, 2007). Animal identification is an important step in most animal monitoring methods, and it has been implemented in a variety of different ways for different animals. Fish and rats are usually monitored (Spink et al., 2001; Ardekani et al., 2013) in a highly controlled environment, possibly using additional markers to identify individual animals, with the primary focus on monitoring repetition of a specific action and/or the duration of the action. Some research has also been done in monitoring insects, but they are particularly challenging subjects to track due to their small size and similarity (Hendriks et al., 2012). In bat movement analysis (Breslav et al., 2012) the main interest is to identify individual animals and compare their flying trajectories.

More research has been done in monitoring cows', chicken broilers' and pigs' behavior. A study by Cangar et al. (2008) used a model-based monitoring tool to track locomotion and posture of pregnant cows' in a pen. Studies by Dawkins et al. (2009, 2012) and Roberts et al. (2012) on chicken behavior analysis use low level features of OF to monitor chickens' welfare. Pigs can be tracked using radio tags that are attached to the animal's ear (Ng et al., 2005) or injected in the animal's body (Prola et al., 2010; Caja et al., 2005), or using video surveillance. For example, Tu et al. (2013) and Guo et al. (2014) use background subtraction methods to identify pigs in a frame. Their methods can handle illumination changes, which is different from our case that involves controlled illumination. Pigs were also tracked in a pen using markers (Kashiha et al., 2013), features (Ahrendt et al., 2011) or shape matching (Tillett et al., 1997). The feature based approach successfully tracks pigs without loosing them for eight-minutes. The computer vision methods are used to monitor not only the pig' behavior but also the activity levels in relationship to the climate in a pen (Costa et al., 2014), to measure pigs' weight (Kashiha et al., 2014) and to analyze pigs locomotion (Kongsro, 2013). None of the methods for animal monitoring in the literature analyze cases where the animals can enter and leave the surveyed area. Such unconstrained areas are on the other hand very common in human crowd monitoring (Kratz and Nishino, 2009; Perko et al., 2013) and the corresponding analysis is often carried out using OF as we also propose in our study.

2. Animals and setup

The pigs were recorded at a Danish slaughterhouse during the unloading process from the truck. The pigs were transported for around 2 h from the fattening houses to the slaughterhouse in commercial three-deck trucks. The pigs in the truck were divided into pens of 15–23 pigs each. There were 9–15 adjustable size pens in a truck. The majority of the pigs are crossbreeds between Duroc, Danish Landrace and Yorkshire (Dx(LxY)). The recordings mainly contain white-skinned pigs with a few colored pigs. Pigs weighed 100–110 kg and were approximately 6 months of age.

The setup of the unloading area is shown in Fig. 2. The pigs are transferred from the trucks to unloading dock and from there they enter the slaughterhouse. The average temperature of 14.8 °C was recorded during the unloading.

A GoPro HERO2 (©2013 Woodman Labs, Inc) camera was used for recording. A sample frame of the videos recorded is given in Fig. 3. The entire frame is not analyzed as the pigs can only move in a certain area of the frame.

Three videos, each of length 17 min 35 s, were recorded at the rate of 29.97 frames per second. The frame height is 1920 and