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Vision-based method for tracking meat cuts in slaughterhouses

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ABSTRACT

Meat traceability is important for linking process and quality parameters from the individual meat cuts back to the production data from the farmer that produced the animal. Current tracking systems rely on physical tagging, which is too intrusive for individual meat cuts in a slaughterhouse environment. In this article, we demonstrate a computer vision system for recognizing meat cuts at different points along a slaughterhouse production line. More specifically, we show that 211 pig loins can be identified correctly between two photo sessions. The pig loins undergo various perturbation scenarios (hanging, rough treatment and incorrect trimming) and our method is able to handle these perturbations gracefully. This study shows that the suggested vision-based approach to tracking is a promising alternative to the more intrusive methods currently available.

1. Introduction

In recent years, traceability has become an increasingly important aspect of the meat industry. For consumers, meat safety and quality is a persistent concern strengthened by reoccurring food recalls and scandals as well as increased animal welfare awareness (Vanhonacker, Verbeke, Poucke, & Tuyttens, 2008). In Western markets, this public concern has lead to legislations and regulations regarding food traceability to ensure quality and safety standards (Trienekens & Zuurbier, 2008). For producers, traceability adds extra value to their end products (Wang & Li, 2006). Demand for traceability information is on the rise yielding a competitive advantage to the producers who can deliver better guarantees of origin and handling (Buhr, 2003; Carriquiry & Babcock, 2007; Pouliot & Sumner, 2008).

In industrial abattoirs individual meat cuts become hard to trace after having cut up the carcass. Today most tracking systems are based on secondary systems like boxes or Christmas trees with RFID technology or conveyor belts. These systems offer only batch-level tracking of meat cuts because the secondary devices cannot be attached to the products individually.

In this work we propose a new technology for enabling meat traceability of individual meat cuts in slaughterhouse environments. Our approach is based on modern methods from the field of computer vision and image processing. Instead of attaching identification information to an object in order to track it we capture an image of the object and can identify the same object at a later point by capturing a new image. That is, we extract a *description* of an object from its appearance and use it as identifier for that object. We believe that this approach offers attractive advantages compared to current technology. While our experiments are limited to tracking pork loins, the method is sufficiently generic to be applied in other domains where the objects exhibit adequate diversity in appearance like the meat cuts considered in this work.

1.1. Related work

Food traceability has been approached from many angles with different applications in mind. This has led to a diverse literature with a limited agreement on how to implement food traceability. For an overview of food traceability literature, we refer to Karlsen, Dreyer, Olsen, and Elvevoll (2013).

In this article, we focus on a single aspect of traceability in the meat industry; the technology that enables object tracking along a production line. In recent literature, the use of RFID tags as underlying food tracking technology is dominating (Cimino & Marcelloni, 2012; Lefebvre, Castro, & Lefebvre, 2011; Regattieri, Gamberi, & Manzini, 2007). However, RFID tagging of meat in a slaughterhouse environment has drawbacks for mainly one reason: Tags may disappear into the meat product and turn up on the consumer's plate. This is a very critical point with the consequence that slaughterhouses avoid tagging meat cuts directly; instead they attach a tag to the device carrying the meat.

Regarding tracking technology in the meat industry, the following approaches have been suggested. Mousavi, Sarhadi, Fawcett, Bowles, and York (2005) present a conveyor belt system capable of tracking

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meat cuts in a boning hall. To facilitate the tracking, RFID chips are embedded in carrier hooks for the meat cuts. Fröschle, Gonzales-Barron, McDonnell, and Ward (2009) examine the usability of barcodes printed on the beak and legs of chickens. This approach does not generalize well to other meat tracking scenarios because it requires the meat product to have non-edible parts suitable for barcode printing. Arana, Soret, Lasa, and Alfonso (2002); Suekawa et al. (2010) perform breed identification of beefs based on DNA analysis, and Tate (2001) investigates the possibility of using DNA analysis for tracing individual meat cuts back to the original carcass. Our vision-based approach is reminiscent of DNA identification in the way identification is derived from the object rather than from a tag attached to the object. However, DNA identification is still a cumbersome process for a slaughterhouse environment.

Of the three tracking technologies mentioned above, the conveyor belt system is most representative of current slaughterhouse practice. Typically, meat cuts are tracked individually or in a batch by attaching a tag to the container or carrier device. A drawback of this method is that it is prone to accidents where pieces are lost or exchanged between carrier devices. Such accidents may happen since the meat cuts cannot be directly connected to the carrier device at all times. With a vision-based approach, this scenario will not be a problem since the meat cut carries identification in its appearance.

For both the food and the non-food industry we have not been able to find examples of visual recognition methods similar to ours applied in a tracking/identification setup. Weichert et al. (2010) propose combining RFID tracking with a vision system that can recognize and decode 2D barcodes. Using cheap cameras they can offer a more continuous identification and localization of the products and thereby improve fault detection. Again, this approach is not viable for meat cuts as the goal is to avoid foreign objects (both barcodes and RFID tags) that can end up in the product. Therefore, to the best of our knowledge, tracking from visual recognition of the products directly has not been attempted before.

1.2. Contributions

In this work we investigate a new technology for enabling traceability of individual meat cuts in a slaughterhouse environment. The investigation extends the work presented by Hviid, Jørgensen, and Dahl (2011) by scaling up the experiment to 211 pork loins and introducing *nuisance factors* to simulate a slaughterhouse environment. We show that the pork loins can be recognized and identified correctly between the two photo sessions. These results indicate that current computer vision methods for object recognition are mature for integration in production lines.

2. Experiment setup

The dataset for our experiment is constructed using 211 pig loins. The pig loins are photographed in two sessions separated by 1 day. Overnight, the loins are hanging on *Christmas trees* stored in a chill room, see Fig. 1.

The photographing setup (see Fig. 2) is the same for both photo sessions. We use the popular and inexpensive Microsoft Kinect camera that captures a depth map along with a standard RGB image of the loin. Examples of both images are shown in Fig. 3. Next to the camera a fluorescent tube is mounted spreading light at a wide angle. The loins are photographed separately by placing them one by one on a table and capturing a photo.

A selection of the loins undergoes different perturbation scenarios in an attempt to simulate slaughterhouse treatment. All perturbations occur after the first and before the second photo session. The perturbations are:

Rough treatment 19 loins are knocked hard onto a table before the second photo session.

Incorrect trimming Pieces of meat and bones are cut off from 18 loins before the second photo session.

Incorrect hanging 19 loins are stored overnight by hanging them sideways on Christmas trees which causes bends.

Fig. 1. Pork loins are stored overnight on *Christmas trees* between the two photo sessions.

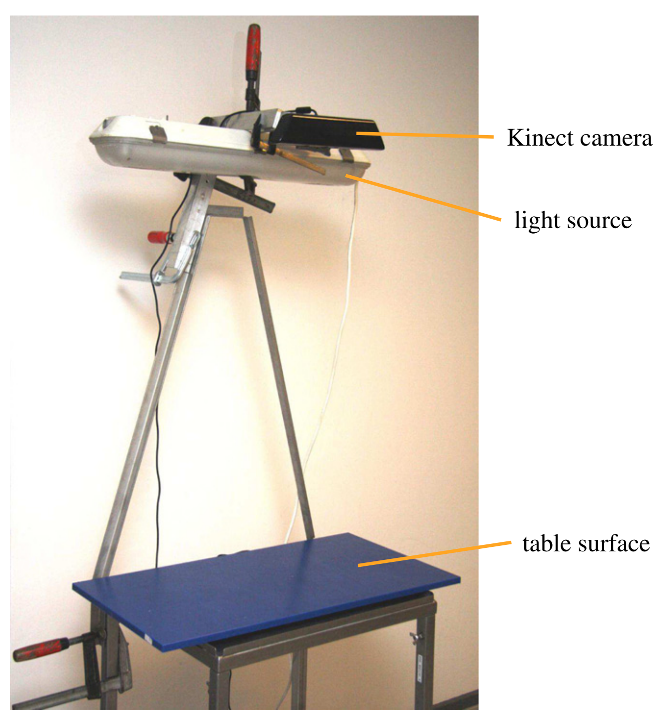

Fig. 2. Camera setup. Pork loins are placed on the table and are photographed from above.