Noise Resistant Morphological Algorithm of Moving Forklift Truck Detection on Noisy Image Data

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ABSTRACT

In this paper the authors focus on the specific problem of machine vision, namely, the video-based detection of the moving forklift truck. It is shown that the detection quality of the state-of-the-art local descriptors (SURF, SIFT, etc.) is not satisfactory if the resolution is low and the illumination is changed dramatically. The authors propose a novel algorithm to detect the presence of a cargo on the forklift truck on the basis of the mathematical morphological operators. At first, the movement direction is estimated with the updating motion history image method and the front part of the moving object is obtained. Next, contours are detected and the morphological operations in front of the moving object are used to compute several geometric features of an empty forklift. In the experimental study, it has been shown that the proposed method has 40% lower false positive rate and 27% lower false negative rate in comparison with conventional matching of local descriptors. Moreover, this algorithm is 7-35 times faster.

Keywords: Binary Morphology, Keypoints Detection, Local Descriptors, Motion History Image, Noisy Environment, Video-based Object Detection,

INTRODUCTION

Nowadays computer vision is widely applied in the industry. One of the most acute problems is the creation of automatic real-time controllers of production lines. In this paper, we consider quite specific, but practically important task in the field of video-based object detection, namely, the detection of a moving forklift truck and computing its key attributes (moving direction, cargo presence) in case of automation of a route building system in existing cargo warehouse.

It seems that the universal state-of-the-art object detectors can be used in this task. The careful attention should be primarily paid to such algorithms as SURF (Speeded-Up Robust Features)
Bay, Ess, Tuytelaars, Van Gool, 2008), SIFT (Scale-Invariant Feature Transform) (Lowe, 2004), ORB (Rublee, Rabaud, Konolige, Bradski, 2011) and FAST (Rosten, Porter, Drummond, 2010). These algorithms detect the keypoints and compute their descriptors on the target image of the object of interest. The same procedure is repeated for each video frame and the similarity between keypoint descriptors is computed to obtain an appropriate affine transform of the model object (Lowe, 2004; Savchenko, 2013). Next, this matrix is verified with, e.g., RANSAC method (Forsyth, Ponce, 2002). Finally, an appropriate object tracking method is used to speed-up further processing of detected object (Lucas, Kanade, 1981).

Unfortunately, this approach is highly dependent on the presence of noise in the query video and therefore is characterized with high false negative rate (FNR) and/or false positive rate (FPR) if the noise (variable illumination, shadows, color of light sources, light flashing, partial occlusion of objects, etc.) is present in the images. Thus, the purpose of our research is to reduce the impact of the noise on the object detection accuracy if the video of the moving object is available (Savchenko, 2012a) by using the specific domain knowledge about the object of interest. In such case, the video frame is segmented (Chien, Ma, Chen, 2002) and the moving object’s silhouette may be obtained with the conventional Motion History Image (MHI) method (Ahad, Rahman, Tan, Kim, Ishikawa, 2012). Next, based on information about object orientation, it is possible to compute its key attributes (width, height, area, etc.) using the binary mathematical morphological operations (Shapiro, Stockman, 2001; Najman, Talbot, 2010). Finally, these features are compared with the (known) thresholds determined based on the domain knowledge.

This article is an extended version of the conference paper (Chernousov, Savchenko, 2014). We implemented our algorithm in complete software and provided much more careful experimental study of FPR/FNR of proposed method with addition of various noise to the available video data.

The rest of the paper is organized as follows: in Section 2, we briefly describe the existing solutions for motion and object detection tasks. In Section 3, we formulate the task of the empty moving forklift truck detection. In Section 4, we conduct an experimental study of the detection methods, compare our results within the conventional local descriptors (SURF, SIFT, ORB, FAST) and proposed morphological algorithm, and analyze the algorithms from the point of additive noise resistance. Finally, we present the findings and give concluding comments.

RELATIVE WORKS

The solution of our task of moving forklift truck detection is based on two fundamental computer vision tasks, namely, the detection and tracking of the moving objects and identifying their specific attributes (e.g., type of the forklift or the presence of the cargo). These tasks are well-known in computer vision and there are plenty of methods to solve them. Hence, in this section we primarily focus only on the state-of-the-art approach, which is suitable for most of practical applications. There are several popular conventional methods to video-based object detection and tracking, for instance, frame subtraction (Kiyoharu, Huang, 1995), background subtraction (Piccardi, 2004; Neria, Colonnese, Russo, Talone, 1998), Motion History Image (Ahad et al., 2012) and Optical Flow (Aires, Santana, Medeiros, 2008). Each method has its benefits and drawbacks.

Frame subtraction is a common method in preliminary motion detection on which the decision about the presence of the movement in a frame sequence is made. In this algorithm, the per-pixel difference between two consequent frames is calculated. These values are then compared with a fixed threshold. The result is a binary movement mask. Described method is quite adaptive to the environment changes but is not appropriate for detecting of image features.
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