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Smoke Detection in Video: An Image Separation Approach

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Abstract Existing video-based smoke detection methods often rely on the visual features extracted directly from the original frames. In the case of light smoke, the background is still visible and it deteriorates the quality of the features. This paper presents an approach to separating the smoke component from the background such that visual features can be extracted from the smoke component for reliable smoke detection. Specifically, an image is assumed to be a linear blending of a smoke component and a background image. Given a video frame and its background, the estimation of the blending parameter and the actual smoke component can be formulated as an optimization problem. Three methods based on different models for the smoke component are proposed to solve the optimization problem. Experimental results on synthesized and real video data have shown that the proposed approach can effectively separate the smoke component and the smoke detection performance is significantly improved by using the visual features extracted from the smoke component.

Keywords Smoke detection · Smoke texture · Image separation · Sparse representation

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1 Introduction

The presence of smoke often signals the onset or possibility of a fire event. Thus, early detection of smoke can serve as a warning for incidence of fire. Conventional point smoke detectors, which include photoelectric and ionization detectors, mainly detect the presence of certain particles generated by smoke and fire. Photoelectric detectors make use of photometry to detect the presence of these particles. Ionization detectors achieve this by means of monitoring the reduced quantities of ionized air molecules. Both methods depend on the transportation of the smoke towards the detector and sufficient concentration of the molecules or particles being present. There is a delay inherent in the transportation and this is exacerbated in outdoor scenario where there could be draught or wind. Smoke detectors used in open areas require to be in close proximity of the source in order to be effective. Apart from the limitation of proximity these detectors do not provide information about the location of the fire, its burning rate or other key indicators.

Compared to the methods described above, visual inspection and detection do not suffer similar drawbacks. Recent advances in real-time video-based surveillance techniques have made vision-based smoke detection a promising approach to early detection of fire. Vision-based smoke detection is suitable in both enclosed and open spaces and there is an additional benefit of being able to specify the location of the fire, its scale and intensity.

Most vision-based smoke detection techniques adopt a pattern recognition paradigm in which the input image or video is preprocessed and divided into blocks. For each block, salient features are extracted and employed to classify the block into smoke and non-smoke. The success of these techniques depends on identifying robust visual features that can characterize smoke and to this end, there are reported studies

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