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Combining Multi-Channel Color Space with Local Binary Co-occurrence Feature Descriptors for Accurate Smoke Detection from Surveillance Videos

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Abstract
Fire is one of the most devastating hazards that can cause serious damage to human life, health and property. As smoke is often an initial sign of fire, smoke detection using surveillance cameras is key to providing early alarm in open space environments. In this paper, we propose a new feature extraction method that combines local binary patterns with co-occurrence of texture features in RGB color space to characterize the diverse manifestations of smoke. The proposed RGB color based Local Binary Co-occurrence Patterns (RGB_LBCoP) extracts smoke features from candidate smoke regions which are extracted by Fuzzy C-Means (FCM) algorithm. Subsequently, Support Vector Machine (SVM) is used for training and classification based on these features. The major benefit of the proposed feature descriptor is the ability to incorporate local and global texture properties of smoke along with color information. This property enables the detection of smoke in complex environments and provides insensitivity to illumination changes. For validation, performance of the proposed method is compared with other LBP variants and Grey-level co-occurrence matrix (GLCM). Experimental analysis on publicly available smoke video datasets demonstrates that the proposed algorithm outperforms the other methods by achieving an average True Positive Rate (TPR) of 92.02%.

Keywords: *Smoke Detection, RGB Color Space, Local Binary Co-occurrence Patterns, Local and Global Features, Surveillance Videos*

1. Introduction

Traditional smoke detection sensors which are cheap and simple to use, detect the presence of smoke, heat or radiation by sampling smoke particles, atmospheric temperature and relative humidity [1]. However, these sensors suffer from the propagation delay of the smoke particles as they trigger when sufficient amounts of smoke particles reach near the sensors. Hence, smoke sensors demand conditions like proximity to fires as well as good operating conditions. Further, they are not suitable for application in open space environments. Furthermore, these types of point sensors cannot provide the actual position and size of the fires. In contrast, video cameras can be used to overcome the aforementioned limitations by monitoring the volumes of fire with information about their size and growth rate. Hence, video surveillance cameras, which are widely used in security applications, can be used in fire monitoring systems for open spaces. For open spaces, initially smoke might appear in the surveillance cameras as fire is obstructed by the foliage in forests and infrastructures in built-up areas. Therefore, detecting smoke can give an early warning for fire hazards.

Various approaches have been proposed in recent years with the aim of efficient detection of smoke in video sequences so that it can be applicable for real time applications. One of the main challenges of video based smoke detection is to extract smoke features as it presents diversely with quite chaotic variations in color, shade, motion and density. For this reason, feature extraction has been widely investigated in the literature. Cetin et al [2] summarized the existing smoke and fire detection techniques based on video surveillance cameras and computer vision methods. The authors provided a comprehensive overview about color, motion, flicker, dynamic texture and spatio-temporal descriptor features which are currently available in the state-of-the-art works. Töreyin et al.[3] used temporal and spatial wavelet analysis to detect semi-transparent smoke for a static camera. Gubbi et al. [4] characterized smoke by detailed wavelet features which were extracted from the three levels of wavelet transformation. Then these wavelet features were used by SVM to detect smoke. A model