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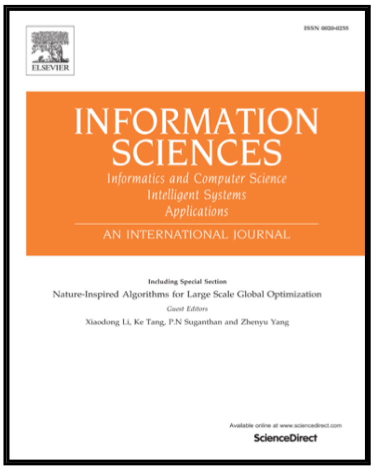

High-order local ternary patterns with locality preserving projection for smoke detection and image classification

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High-order local ternary patterns with locality preserving projection for smoke detection and image classification

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***Abstract*—It is a challenging task to recognize smoke from visual scenes due to large variations in the color, texture, shapes of smoke. To improve detection accuracy, we propose a novel feature extraction method by encoding high order directional derivatives at each pixel. We first quantize the directional derivatives into ternary values to generate Local Ternary Patterns (LTP). For the sake of simplification, each LTP code is usually decomposed into an upper LBP code and a lower LBP code, but this leads to loss of information. Hence, we use joint histograms to preserve the co-occurrence of upper and lower LBP codes for each order LTP. Then we concatenate all joint histograms from different orders to propose High-order Local Ternary Patterns (HLTP). To improve computational efficiency, we apply Locality Preserving Projection (LPP) to reduce the dimension of HLTP. To further improve performance, we present a noise resistant mechanism to remove noisy derivatives, and then propose HLTP based on Magnitudes of noise removed derivatives and values of Center pixels (HLTPMC). Finally, the Support Vector Machine (SVM) is used for training and classification. Experiments on large scale smoke data sets show that our method can achieve detection rates above 94% with false alarm rates below 1.33%. Experiments on a multi-class Brodatz texture data set also achieved good performance with low dimensional features. So our method has powerful discriminative capabilities and compact feature representation for multi-class image classification.**

***Keywords*—Local Ternary Patterns, High order Derivatives, Locality Preserving Projection, Smoke Detection, Image Classification.**

1. Introduction

Traditional fire detection methods typically use point based sensors that are implemented by smoke particle sampling, atmosphere temperature sampling, relative humidity sampling, or other analyses [51]. Traditional fire sensors are widely applied because they are simple, cheap and accurate. However, traditional fire sensors have various shortcomings that are difficult to solve. Exposure of traditional fire sensors to combustion products is required because these sensors need to analyze particles, temperature or humidity. Hence, traditional fire sensors must be installed in close proximity to fires. This limits conventional fire detection technologies to applications only in small or indoor spaces. In addition, it may take a long time to transfer combustion products, such as smoke particles, to fire sensors, resulting in slow response.

To overcome the above mentioned limitations of traditional fire detection methods, fire detection from visual scenes has been widely investigated. Smoke often appears earlier than flames, so smoke detection provides earlier fire alarms than flame detection. Earlier fire alarms play an important role in fire extinguishment and personnel evacuation. A variety of algorithms have been proposed for smoke detection in recent years. Toreyin *et al.* [41] proposed smoke detection by fusing features of motion, flicker, edge blurring and color. Gubbi *et al.* [9] computed the arithmetic mean, geometric mean, standard deviation, skewness, kurtosis, and entropy over each sub-band of three level wavelet transformed images and then used Support Vector Machine (SVM) to detect smoke from videos. Gottuk *et al.* [8] evaluated the effectiveness of commercial video fire detection systems for small and cluttered spaces on navy ships and concluded that video fire detection systems can detect fires more accurately and efficiently than traditional systems in specific spaces. In our previous work, we proposed a fast accumulative

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