Gaussian Convolution Angles: Invariant Vein and Texture Descriptors for Butterfly Species Identification

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Abstract

Identifying butterfly species by image patterns is a challenging task in computer vision and pattern recognition community due to many butterfly species having similar shape patterns with complex interior structures and considerable pose variation. In additional, geometrical transformation and illumination variation also make this task more difficult. In this paper, a novel image descriptor, named Gaussian convolution angle (GCA) is proposed for butterfly species classification. The proposed GCA projects the butterfly vein image function and intensity image function along a group of vectors that start from a common contour points and ends at the remaining contour points which results a group of vectors that capture the complex vein patterns and texture patterns of butterfly images. The Gaussian convolution of different scales is conducted to the resulting vector functions to generate a multiscale GCA descriptors. The proposed GCA is not only invariant to geometrical transformation including rotation, scaling and translation, but also invariant to lighting change. The proposed method has been tested on a publicly available butterfly image dataset that has 832 samples of 10 species. It achieves a classification accuracy of 92.03% which is higher than the benchmark methods.

Method

In this paper, a novel image descriptor, named Gaussian convolution angle (GCA) is proposed for butterfly species classification. Gaussian convolution angle consists of Gaussian Convolution Vein Angle and Gaussian Convolution Texture Angle.

Fig. 1. Illustration of the process of generating Gaussian convolution vein angle (GCVA). Left: the curve of the Gaussian function $G_\sigma(r)$ used for convolution; Middle: The right vectors (marked in red colour) and the left vectors (marked in green colour) that starts from a common contour point and ends at the other contour points; Right: The resulting right convolution vector (marked in bold line with red colour) and left convolution vector (marked in bold line with green colour) and the angle (named GCVA) between them.

Fig. 2. Illustration of the process of generating Gaussian convolution texture angle (GCTA). Left: the curve of the Gaussian function $G_\sigma(r)$ used for convolution; Middle: The right vectors (marked in red colour) and the left vectors (marked in green colour) that starts from a common contour point and ends at the other contour points; Right: The resulting right convolution vector (marked in bold line with red colour) and left convolution vector (marked in bold line with green colour) and the angle (named GCTA) between them.

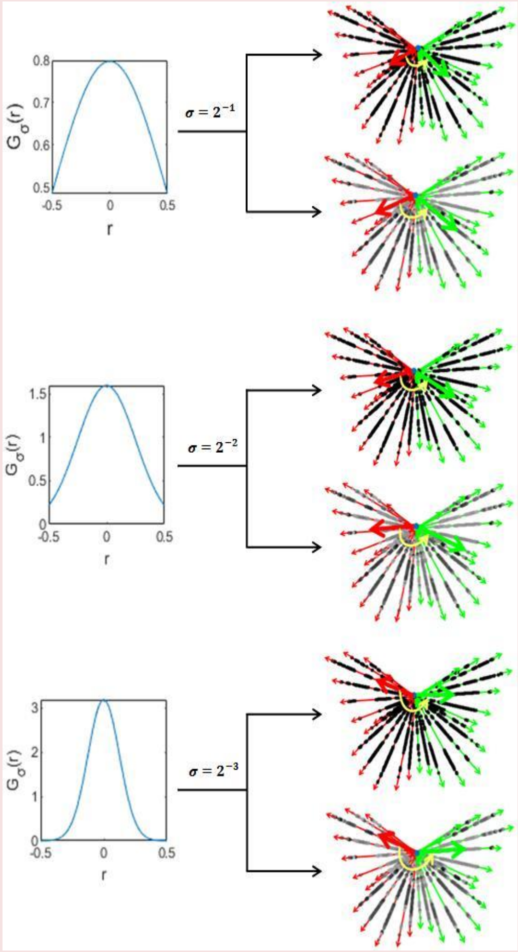

Fig. 3. The Gaussian convolution vein angles and texture angles of the butterfly image shown in Fig. 2 at scale $\sigma = 2^{-1}, 2^{-2}$ and 2^{-3}.

Conclusion

A novel image descriptor, Gaussian convolution angle (GCA), including Gaussian convolution vein angle (GCVA) and Gaussian convolution texture angle (GCTA), has been introduced for butterfly species recognition. The GCVA and GCTA are derived by integrating the vein image function and texture image function of the butterfly along the contour vector in which the vein and texture structures of the butterfly image are finely captured. The Gaussian convolution make them present a multiscale description for butterfly image. The proposed GCTA is not only invariant to geometrical transformation, but also invariant to lighting change. The proposed approach is tested on a publicly available butterfly image database and compared with the state-of-the art methods. The experiments convincingly show that the proposed method outperforms the state-of-the art methods on butterfly species recognition.