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

Challenges of butterfly species identification





These two butterflies species have similar shape patterns with complex interior structures.

Two butterflies of the same species have considerable pose variation.

The proposed method - Gaussian Convolution Angle (GCA)

Gaussian Convolution Vein Angle (GCVA)

Gaussian Convolution Angle (GCA)

> Gaussian Convolution Texture Angle (GCTA)

The process of generating Gaussian convolution vein angle (GCVA)



The process of generating Gaussian convolution texture angle (GCTA)



Mathematical definition of Gaussian convolution vein angle (GCVA) and Gaussian convolution texture angle (GCTA)

The right Gaussian convolution vein vector is defined as follows

$$\eta_{\sigma}^+(t) = \int_0^{\frac{1}{2}} G_{\sigma}(r) \cdot \xi_t^+(r) \, dr,$$

The left Gaussian convolution vein vector is defined as follows

$$\eta_{\sigma}^{-}(t) = \int_{-\frac{1}{2}}^{0} G_{\sigma}(r) \cdot \xi_{t}^{-}(r) dr,$$

Therefore, the definition of Gaussian convolution vein angle is as follows $\alpha_{\sigma}(t) = \arg(\eta_{\sigma}^{-}(t)/\eta_{\sigma}^{+}(t)),$

Similarly, Gaussian convolution texture angle is defined as follows

 $\beta_{\sigma}(t) = \arg(\delta_{\sigma}^{-}(t)/\delta_{\sigma}^{+}(t)).$

Multiresolution







Experimental results and discussions

TABLE1. The average classification accuracies (%) on the butterfly database

Algorithm	Classification Accuracy (%)
Height Function [13]	71.86
HSC [12]	65.01
RCF[14]	80.83
PHTs[15]	86.16
Zemike Moment [16]	79.43
Proposed	92.03

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 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 experiments convincingly show that the proposed method outperforms the state-of-the art methods on butterfly species recognition.

