Scientific Report

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I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During my ERCIM project, I conducted the research in the department of Image Processing in the Institute of Information Theory and Automation, Prague, Czech Republic. My scientific coordinator is Prof. Jan FLUSSER. Our research was focused on the design of moment invariants and the efficient implementation of high-order invariants.

So far, moment invariants have wide applications in image analysis and pattern recognition. At present, geometric moments are the most used moments due to their simplest basis functions. Still because of the simple basis function, it is relatively easy to derive moment invariants from geometric moments. However, since the basis functions of geometric moments are ever-increasing, there is big risk in numerical overflow when we compute geometric moments or their invariants, especially when the high-order moments or moment invariants are computed. The situation is, therefore, we can not compute geometric moments or moment invariants of order as high as the existing ones, although we know the specific expressions of them. In order to solve this problem, we need use the moments whose basis functions have oscillations in their values. Accordingly, the value of moments or moment invariants will be relatively less than those of geometric moments. This is one reason why we prefer to use orthogonal moments and develop moment invariants from them. Our research therefore contains two aspects: deriving the moment invariants from orthogonal moments and seeking for the method to efficiently implement moment invariants from geometric moments.

We finished some work in the last year. Firstly, we explored the property of Hermite kernel and found that such kernel inherited steerability. This work is useful because Hermite polynomials, Hermite functions, and still Gaussian derivatives, which are frequently used in image processing and pattern recognition, belong to Hermite kernel. So, steerability will be a good property for these tools. Secondly, we successfully developed rotation invariants from Gaussian-Hermite moments in 3D space. A significant theoretical result is proved. It proposed a method which constructs the rotation invariants from Gaussian-Hermite moments based on geometric invariants. Still, we proposed an approach how to compute high-order invariants from Gaussian-Hermite moments.

I gave a presentation of my work after I joined in the department of Image Processing. I still attended the ERCIM seminar held on 24-25 Oct. 2012. Two REP programs have been conducted in Hungary and France. One paper has been accepted and other two are under polishing and they will be submitted shortly in a month.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

1. Bo Yang, Jan Flusser, Tomas Suk, “Steerability of Hermite kernel”, International Journal of Pattern Recognition and Artificial Intelligence, Accepted.

   Abstract: Steerability is a useful and important property of “kernel” functions. It enables certain complicated operations involving orientation manipulation on images to be executed with high efficiency. Thus, we focus our attention on the steerability of Hermite polynomials and their versions modulated by the Gaussian function with different powers, defined as the Hermite kernel. Certain special cases of such kernel, Hermite polynomials, Hermite functions and Gaussian derivatives are discussed in

detail. Correspondingly, these cases demonstrate that the Hermite kernel is a powerful and effective tool for image processing. Furthermore, the steerability of the Hermite kernel is proved with the help of a property of Hermite polynomials revealing the rule concerning the product of two Hermite polynomials after coordination rotation. Consequently, any order of the Hermite kernel inherits steerability. Moreover, a couple sets of an explicit interpolation function and basis function can be directly obtained. We provide some examples to verify steerability of the Hermite kernel. Experimental results show the effectiveness of steerability and its potential applications in the fields of image processing and computer vision.

2. Bo Yang, Jan Flusser, Tomas Suk, "3D rotation invariants from Gaussian-Hermite moments", ready for submission to Pattern Recognition in June.

   Abstract: 3D rotation invariants based on orthogonal Gaussian-Hermite moments are proposed in this paper. Dislike the traditional methods which derive the invariants from the basis functions of the moments directly, the proposed method uses an indirect way. By comparing the formations of geometric moments with those of Gaussian-Hermite moments before and after rotation in 3D space, we draw the conclusion that the constructing formations of 3D rotation invariants of Gaussian-Hermite moments are identical to those of invariants of geometric moments. Both mathematical proofs and numerical experiments are supplied to verify the invariance and evaluate the performances of this new type of invariant.

3. Bo Yang, Jan Flusser, Tomas Suk, "An approach to compute high-order Gaussian-Hermite moments", in preparation.

   Abstract: Rotation invariants play important roles in pattern recognition. So far, most rotation invariants are derived from geometric and complex moments. In spite of this, high-order rotation invariants have been rarely developed from the moments other than geometric and complex moments. In this paper, we propose a method to compute rotation invariants from orthogonal Gaussian-Hermite moments, especially the invariants of high order. This method is taken advantage of the relation between geometric and complex moments and that between rotation invariants of geometric and Gaussian-Hermite moments. Firstly, it generates rotation invariants from complex moments. Secondly, it represents every complex moment by geometric moments in the expressions of the generated invariants. Finally, a rotation invariant from Gaussian-Hermite moments can be achieved by replacing geometric moments with the corresponding Gaussian-Hermite moments. Some high--order invariants computed by this method are tested to verify their rotation invariance, evaluate their recognition ability and noise robustness. The results show that the proposed method is effective to compute rotation invariants of Gaussian-Hermite moments.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

1. ERCIM seminar, INRIA Sophia Antipolis, France, 24, Oct. 2012

IV – RESEARCH EXCHANGE PROGRAMME (REP)

1. My first visitation was hosted by Prof. Dmitry CHETVERIKOV in MTA SZTAKI Hungary, 17 Mar. to 30 Mar. 2013.

   I gave a presentation during my visitation. Prof. CHETVERIKOV and his colleagues introduced their excellent work in geometric modelling and computer vision. I got some useful information and techniques of texture analysis, image segmentation, and multi-view reconstruction. I also visited their 3D/4D reconstruction studio.

2. My second visitation was hosted by Prof. Edmond BOYER in INRIA Grenoble Rhone-Alpes, France, 16 Apr. to 27 Apr. 2013.

   Prof. BOYER and his colleagues showed their work in computer vision. I got some useful knowledge about multi-view reconstruction. I was impressed by their work on spatio-temporal shape modelling and photo-realistic dynamic models. I still made a presentation about my work and got some valuable advices from these experts on moment computation from objects represented by 3D mesh.