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PAPER TITLE: Adaptive directional lifting-based wavelet transform for image coding

AUTHORS: Wenpeng Ding, Feng Wu, Xiaolin Wu, Shipeng Li, Houqiang Li

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NOMINATING TECHNICAL COMMITTEE: IVMSP TC

NAME, ADDRESS, E-MAIL ADDRESS, PHONE AND FAX OF NOMINATOR:

Majid Rabbani, Eastman Kodak Company

Majid.rabbani@kodak.com; phone: +1.585.477.3722

NAME, CURRENT ADDRESS, E-MAIL ADDRESS, PHONE, AND FAX OF AUTHORS:

Wenpeng Ding

Beijing University of Technology, No 100, PingLeYuan, ChaoYang, Beijing, China, 100124

Email: wpding@gmail.com

Phone: +86-10-67396568 ext. 2108, Fax: +86-10-67396568

Feng Wu

Microsoft Research Asia, No. 5 Danling Street, Haidian District, Beijing, China, 100080

Email: fengwu@microsoft.com

Phone: +86-10-59173119, Fax: +86-10-88099511

Xiaolin Wu

McMaster University, Hamilton, Ontario, Canada, L8G 4K1

Email: xwu510@gmail.com

Phone: +1-905-5259140 ext. 24190, Fax: +1-905-521-2922

Shipeng Li

Microsoft Research Asia, No. 5 Danling Street, Haidian District, Beijing, China, 100080

Email: spili@microsoft.com

Phone: +86-10-59175789, Fax: +86-10-88099511

Houqiang Li

University of Science and Technology of China, 443 Huangshan Rd, Hefei, China, 230027

Email: lihq@ustc.edu.cn

Phone: +86-551-3601340

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Natural images inherently contain rich directional structures, beyond simple horizontal or vertical lines, as in the contemporary digital images we perceived today. It is true that conventional rectilinear transforms we have been using to represent them are unable to fully capture such directional correlations. Recent efforts in developing new directional transforms (e.g., RidgeLet, CurveLet and ContourLet) are elegant and mostly based on filter banks. However, these directional transforms have not yet achieved its full potential when applied to the coding of natural images.

For any transform to become superior in coding of natural images, not only does it need to properly capture the directional correlation, it needs to generate the transform coefficients in such a way that they can be optimally encoded by subsequent entropy coding strategies. It is based on such challenging principle that this paper proposes an innovative mechanism to design a directional transforms through incorporating directional operators in the lifting structure.

Such directional lifting-based transform demonstrates “out-of-the-box” thinking and is capable of offering several benefits beyond existing directional transforms for image coding: (1) This lifting-based transform can represent a natural image with similar coefficient structure and distribution as their conventional counterparts. This way, there is no need to re-design subsequent entropy coding and other coding components. (2) This lifting-based strategy is universal in that a directional transform can be derived from its non-directional counterpart provided that the original transform can be implemented by a lifting structure. None of the existing directional transforms can be so easily derived. To demonstrate the unique advantages, this paper proposes a directional wavelet transform to replace the conventional wavelet transform in the state-of-the-art image coding schemes, JPEG 2000 and SPIHT. It has been confirmed by extensive experimental results that the proposed scheme outperforms JPEG 2000 and SPIHT in both PSNR and visual quality, with the improvement up to 2.0 dB on images with rich orientation features.

The follow-up schemes include directional DCT transform (T-CSVT, 2007) and directional lapped transform (T-IP 2010) by using the same mechanism. Both of these schemes achieve consistent performance gains over JPEG and JPEG XR similar to JPEG 2000 and SPIHT.

The original paper and their follow-up papers have been widely cited by researchers in this vibrant community. There are well-over 220 combined citations for the original paper (120+) and the subsequent papers.

The idea presented in this paper is pioneering and novel and the results are solid and convincing. The content is carefully organized, the description is clear, and the discussion is insightful. The topic is of great interest to a broad community. I strongly recommend that the paper be considered for the best paper award. I believe that the researchers in the relevant communities will benefit significantly from the well-conceived ideas presented and the conclusions obtained in this paper.