

EE398B Project Proposal

Light Field Compression with 4D Wavelet Based On Disparity-Compensated Lifting

Chuo-Ling Chang
chuoling@stanford.edu
ZHU Xiaoqing
zhuxq@stanford.edu

1. Background

Light field is a representation of 3D static scene that captures all the outgoing radiance at all positions in all directions. In free space it is a 4D function that can be sampled as a 2D array of images. The amount of light field data is usually huge; therefore compression is necessary for its storage, transmission and manipulation. Aside from high compression ratio, other desirable features of a light field coder include random access for image-based rendering purposes, and scalability for progressive transmission over network.

2. Related Work

Over the years a number of methods such as vector quantization (VQ), predictive coding, etc, have been tried out with light field compression. However, it is hard to achieve all the desired features all at once. Although wavelet schemes are very attractive due to its multi-resolution representation characteristic, previous efforts which directly applied 4D DWT to light field data yielded unsatisfactory results, since parallax between neighboring images introduced many non-zero coefficients in high-frequency subbands. Also, texture-map approaches, while providing a solution to the problem of image disparity from different viewpoints, had to sacrifice reversibility and image resolution due to the resampling process involved.

3. Proposed Scheme

In our project we plan to try on a scheme that can incorporate disparity-compensation into the ingenious lifting framework as implementation of the 4D DWT. The idea is inspired by the recently introduced motion-compensated lifting scheme, originally applied to video coding. For our 4D light field data, the disparity-compensation operation would then be analogous to the motion-compensation in videos. As a mini-research, we shall look into different elements within the lifting framework and try to evaluate their influence on the resulting performances, such as compression efficiency, computational cost, decoding speed, and ease of random image strip retrieval. The issues that we are interested in include but are not limited to:

- a) choice of wavelet kernels: Haar, 5/3 bi-orthogonal, etc
- b) decomposition levels: from 1 to 6, may be different for each dimension
- c) boundary extension methods: zero stuffing, symmetric, arbitrary, circular
- d) disparity-compensation methods: warping with an estimated (for natural objects) or given (for synthetic scene) geometry model or search along epipolar line by block matching approach (for general scene with no appropriate geometry information)

It is noted that in order to compare our work with results from previous research, we also need a highly efficient entropy coder for the wavelet coefficients to obtain exact compression ratios. However, implementation of a 4D SPIHT coder might be unrealistically time-consuming for a quarter's project. We therefore plan to first estimate our compression efficiency by with the following analysis:

- a) compare the coding gain for Disparity-compensated DWT with that of direct 4D DWT
- b) simply compressing each individual images after transform using standard JPEG2000 toolbox. This way we can get a lower bound on the compression ratio.
- c) Encode the coefficients with a 3D SPIHT coder, which is designed for video compression and may be directly available from the SPIHT homepage. Still we shall waste the correlation between the transform coefficients along one dimension.

However, the improvement in compression ratio from the 2D case, if there is any, shall give us a better idea about how 4D SPIHT will contribute to the system.

Reference:

- 1] D. Taubman and M. Marcellin, JPEG2000: Image Compression Fundamentals, Standards and Practice. Boston: Kluwer Academic Publisher, 2001
- 2] Andrew Secker and David Taubman, Motion-Compensated Highly Scalable Video Compression Using An Adaptive 3D Wavelet Transform Based On Lifting, ICIP 2001
- 3] Marcus Magnor, Geometry-Adaptive Multi-View Coding Techniques for Image-based Rendering, Ph.D. Dissertation, 2000
- 4] M.Levoy and P. Hanrahan, Light Field Rendering, SIGGRAPH 1996
- 5] Beong-Jo Kim, Z.Xiong, W.A.Pearlman, Low Bit-Rate Scalable video Coding with 3-D SPIHT, IEEE Transactions on Circuits and Systems for Video Technology, 2000