New Methods for Matching Pursuit Video Compression

by

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Abstract

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Matching pursuit is a greedy method for generating a sparse signal representation on an overcomplete dictionary. The method has been successfully applied to video compression, where matching pursuit has been shown to outperform standardized DCT-based codecs in terms of peak signal-to-noise ratio (PSNR) and visual quality. Such quality improvements typically come with an increased encoder complexity cost. However, the decoder complexity of matching pursuit may be less than that of DCT, particularly at low bit rates when DCT-based systems require postfiltering for artifact reduction.

In this thesis, we introduce new methods for matching pursuit video compression which both examine and improve the achievable tradeoffs between complexity and coding efficiency. Such tradeoffs are greatly affected by the design and implementation of the dictionary used for matching pursuit. We thus develop a new method called Dictionary Approximation, which automatically generates fast approximate implementations of arbi-

trary initial dictionaries. In addition to reducing the encoder complexity, the approximation method enables a systematic tradeoff between coding quality and complexity at a given bit rate. It also frees the dictionary design process from initial constraints, which are usually imposed because of complexity considerations.

We also develop new methods for modulus quantization. Early matching pursuit video compression algorithms used a fixed quantizer design which restricted performance at high bit rates. In this work, we introduce an adaptive quantization scheme which seeks to minimize the per-frame distortion for a target bit rate. The result is a 2-pass matching pursuit algorithm which improves coding efficiency, especially at high rates. We also show a 1-pass approximation which preserves most of the coding efficiency gains of the 2-pass system, but does not increase complexity beyond that of the original fixed quantizer design.

Finally, we introduce models which predict the rate-distortion relationship of the matching pursuit video encoder. Such models serve two purposes. First, development of the models gives added insight into the matching pursuit decomposition process. Second, the models may be used to reduce the complexity of rate-distortion based encoder optimization. We evaluate the models in this context, and derive the model-based complexity reductions for several optimization methods from the literature. The results suggest that our models have sufficient prediction accuracy to be used for such optimization, and that significant complexity reductions could be achieved.

Professor Avideh Zakhor
Dissertation Committee Chair

For God,

Tanya,

and my parents

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