北京大学

硕士研究生学位论文

题目：高效视频编码的快速算法技术研究

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摘要

随着互联网的发展与普及，视频应用已经渗透到生活的方方面面。快速增长的视频数据给现有的存储、传输系统带来了巨大的挑战。新一代视频编码标准 H.265/HEVC 比上一代的标准 H.264/AVC 采用更为复杂的编码工具以及灵活的编码模式，压缩效率提升了一倍，编码计算复杂度也明显上升。针对 H.265/HEVC 的快速算法一直是视频编码领域的热点研究问题。

H.265/HEVC 引入了众多可选的编码模式，例如基于四叉树划分结构的编码单元，多达 35 种模式的帧内预测，结合率失真优化的量化等。编码器通过率失真优化的方法综合评测各种编码模式性能，率失真代价小的编码模式组合被判为最优编码模式，这也是造成 H.265/HEVC 计算复杂度高的原因之一。

为了高效地在众多编码模式中寻找最优的编码模式，本文提出了以下几个编码快速算法。

1）提出了基于机器学习的编码单元尺寸快速决策算法。该算法采用离线训练的方式训练双支持向量机分类器，分别用于提高编码单元“划分”与“不划分”类的准确率，降低误判率，以减少编码性能的损失。将训练的分类模型集成到 HEVC 官方参考软件平台，根据实际的编码单元特征，对编码单元是否进一步划分进行决策。该方法在帧内编码配置下可以带来平均 40.23%的编码时间节省，编码性能损失仅为 0.83%。

2）提出了帧内预测模式快速决策算法。充分利用预测单元的主要纹理方向以及主要模式间的相关性，结合当前预测单元的尺寸，设计快速帧内模式决策的算法。该方法在帧内编码配置下实现平均 26.76%的编码时间节省，编码性能损失仅为 0.65%。

3）提出了快速率失真优化的量化算法。分析率失真优化量化的算法复杂度，提出根据编码量化参数和变换块的尺寸快速预测全零块的方法，针对系数分布特殊块提出最优量化系数模型，降低编码器量化的计算复杂度。该方法实现量化部分平均超过 40%的时间节省，编码性能损失仅为 0.03%。

关键词：HEVC，快速算法，编码单元，帧内预测模式，率失真优化的量化

Research on Fast Algorithm of High Efficiency Video Coding

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ABSTRACT

With the development and popularization of the Internet, video applications have penetrated into every aspect of people's lives. Rapidly growing video data has brought huge challenges to existing storage and transmission systems. The new generation video coding standard H.265/HEVC has adopted more complex coding tools and more flexible coding modes than the previous generation of coding standard H.264/AVC. The compression efficiency is doubled, but the computational complexity has significantly increased. The fast algorithm for H.265/HEVC is a hot research issue in the field of video coding.

H.265/HEVC introduces a series of optional coding modes, such as quadtree-based coding units, up to 35 intra-prediction modes, and rate-distortion-optimized quantization. The Rate-distortion Cost (RD Cost) is calculated and encoder comprehensively evaluates the performance among various encoding modes according to the RD Cost. Then, the encoding mode with a low RD Cost is judged as the optimal encoding mode. This is one of the reasons for the high computational complexity of H.265/HEVC.

In order to efficiently find the optimal coding mode, the following several fast algorithms are proposed in this paper.

1) A fast algorithm is proposed for coding unit size decision based on machine learning. This algorithm trains dual support vector machine classifiers with offline training to improve the accuracy of the "splitting" and "non-splitting" classes of coding units. Dual support vector machine classifier is more efficient to reduce the misclassification rate when compared to the traditional single-support vector machine classifier. The training classification model is integrated into the HEVC reference software platform and then, according to the actual coding unit characteristics, the encoding quadtree structure of the coding unit will be pruned or the encoding process of parent node will be skipped. The proposed method can achieve 40.23% encoding time saving with only 0.83% coding performance loss.

2) A fast intra prediction mode decision algorithm is proposed. We make full use of the main texture direction of the prediction unit and the correlation among major modes. The size

of the current prediction unit is also allowed to decrease the number of candidate prediction modes. Over 26% encoding time is saved with 0.65% BD-Rate loss.

3) A fast rate distortion optimized quantization algorithm is designed. In this paper, we first study the complexity of rate-distortion-optimized quantification algorithm. Then we propose a fast detection of all-zero blocks based on the coding quantization parameters and the size of the transform blocks. We also propose a model for selecting the optimal quantized coefficients of the block. By the above method, unnecessary rate distortion-optimized quantization operation is omitted, and over 40% computational complexity of the quantization is reduced with negligible performance loss.

KEY WORDS: HEVC, Fast algorithm, Coding unit, Intra prediction mode, Rate distortion optimized quantization