www.ijecs.in
International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 2 Issue 12, Dec.2013 Page No. 3393-3395

Bandwidth-Oriented Motion Estimation Algorithm For Real Time Mobile Video Application

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ABSTRACT:

Resource-limited systems such as mobile video applications, the available memory bandwidth is dynamically changing and are limited.This project proposes a data bandwidth-oriented motion estimation(ME) design for resource-limited mobile video applications.An integrated bandwidth rate distortion optimization framework is used.This framework predicts and allocates the appropriate data bandwidth for motion estimation under a limited bandwidth supply.The residue number system is used in these framework in order to provide low power consumption and high scalability data bandwidth oriented ME.

Keywords:Low power, Memory bandwidth, Motion Estimation, Video coding, VLSI architecture.

I. INTRODUCTION

MOTION-COMPENSATED temporally predictive coding with motion estimation (ME) is an effective tool for removing temporal redundancy among adjacent frames in modern video encoder designs , which demands high computational complexity and memory bandwidth. These design problems are greater for resource-limited mobile devices, which require a fine tuning of video coding algorithms to better utilize the available resources. To address these design issues in mobile devices, various solutions have been proposed.

The designs in attempted to reduce computational complexity or hardware cost by adopting low-complexity fast algorithms. proposed a complexity rate distortion optimization framework to reduce the complexity of ME operation in a rate-distortion (R-D) sense. Reference introduced a new fast ME algorithm based on an adaptive search range adjustment scheme and a matching point decimation scheme to reduce computational costs. Reference presented pixel truncation to reduce computation and memory access. These designs aim to reduce or consider computational complexity for limited-resource environments.

Meanwhile, the algorithms and architectures. focus on lower power consumption and higher hardware efficiency. To solve the above problems, this paper proposes an optimization framework to allocate the bandwidth for ME computations. We first apply a heuristic approach to develop an analytical bandwidth-oriented model that allocates memory bandwidth according to the R-D gain and bandwidth constraints. Then, we propose a bandwidth-scalable ME algorithm that considers the video contents and bandwidth constraints to reduce memory access and maximize coding performance. In this algorithm, a greater bandwidth is allocated to high-motion MBs while bandwidth is significantly reduced for low-motion MBs. Consequently, the bandwidth is efficiently utilized and minimized to provide the optimal R-D gain. Finally, hardware implementation shows its effectiveness in achieving a higher throughput and lower power consumption than previous designs.

II. OPTIMIZED BANDWIDTH RATE DISTORTION MODELING

In the bandwidth-oriented ME, the coding distortion is not only a function of the used bit rate , but also a function of the available and consumed data bandwidth BW, which can be modeled as However, the overall bandwidth usage of ME is linearly proportional to the SR. Thus, to control the SR in ME, we first introduce a set of bandwidth control parameters. In which, the variable of is a symbol to represent the maximum number of bandwidth control parameter for each system. Accordingly, the SR selection of ME is then a function of these control parameters. The bandwidth requirement of ME, denoted by BW, is a function of SR and is also a function of **B**, denoted by where is the SR selection model of the ME and are bandwidth control parameters. To optimize the bandwidth usage, the available data bandwidth among the MBs should be dynamically allocated according to their motion characteristics, that is, R-D performance. Thus, for a given data bandwidth, the R-D behavior of ME can be well approximated by its R-D gain (*RDGain*, the Lagrange R-D cost difference) where and , respectively, denote the R-D cost at the search center of the motion vector predictor (MVP) and the final best position by the block-matching algorithm under a given BW. The Lagrange R-D cost function here is defined as where is the calculated motion vector and indicates the Lagrange multiplier. The distortion term is the sum of absolute differences between the original signal and the coded video signal .

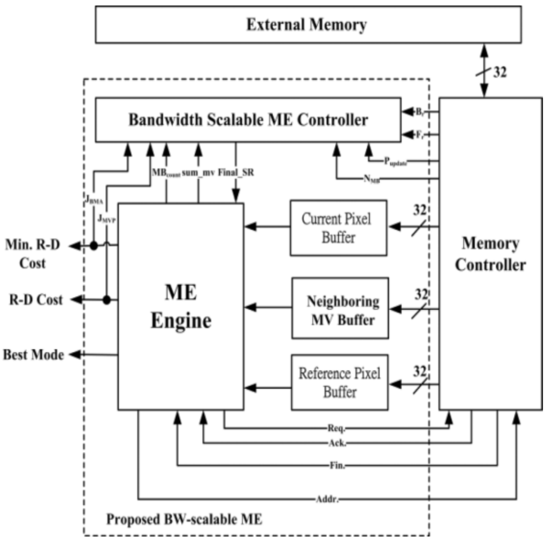


Fig: Block Diagram Of Bandwidth Scalable ME.

Meanwhile, the rate term represents the motion information and the coded bit length of the motion vector difference (MVD) between the motion vector and the motion vector predictor. Thus, we can associate the R-D gain and the bandwidth control parameters with the coding efficiency to perform online bandwidth optimization for real-time video coding in a bandwidth update period .

where denotes the R-D cost of the current coded MB at the position of the MVP, denotes the R-D cost of the current coded th MB after the motion search of the block-matching algorithm. The bandwidth update period denotes the period to update the available system bandwidth, which depends on the system conditions. In general, a shorter period can track the system bandwidth change well, which is more suitable for fast changed environments, but it will also need smart memory controllers which can deliver information of fast bandwidth arbitration change. A longer period can fit into current ordinary memory controllers well with slow bandwidth change. However, with the proposed algorithm shown in the following subsection, we can still adapt to sudden change of system bandwidth and achieve similar performance. In this paper, the is set from one frame to multiple frames. Note that can be changed at any time to adapt to abrupt bandwidth change. With above definition, the operation mode with the greatest coding efficiency should be selected, because it also indicates a better R-D performance gain with equal bandwidth consumption.

III. RNS BANDWIDTH SCALABLE ALGORITHM

The concept of the proposed algorithm is to allocate the available bandwidth in a R-D-optimized sense within the given bandwidth budget. During this allocation, the R-D performance should be kept as smooth as possible for consecutive coding, while the R-D performance should also be maximized within the available bandwidth. However, the true consumed bandwidth is unknown before the real coding process occurs. A reasonable way to accomplish this task is based on using the statistics of past bandwidth usage and R-D performance, that is, the coding efficiency defined in (5), to predict the possible bandwidth usage of the next coding unit. With the above constraints and prediction, an appropriate bandwidth can be allocated to meet the requirements. Note that can be changed at any time to adapt to abrupt bandwidth change. With above definition, the operation mode with the greatest coding efficiency should be selected, because it also indicates a better R-D performance gain with equal bandwidth consumption.

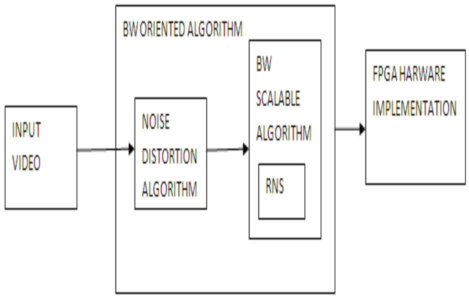


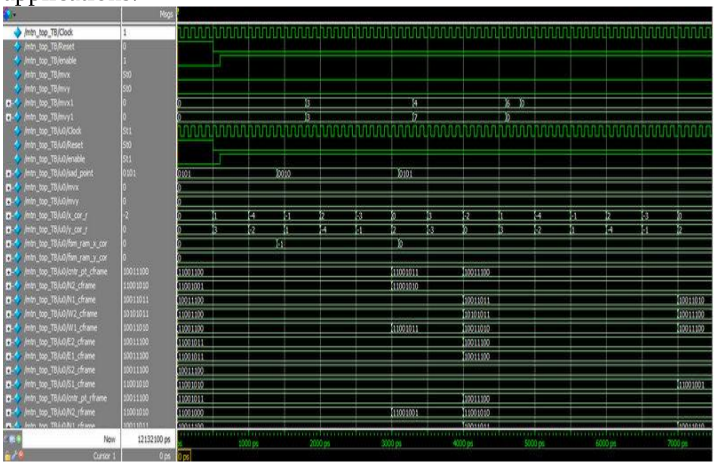
Fig2: Block Diagram Of RNS Bandwidth algorithm.

IV. SIMULATION RESULTS

To evaluate the performance, we integrated our proposed algorithm into JM 12.2 for simulation. The simulation conditions are CIF (352 288)-size and D1 (704 576)-size test sequences with the main profile, no R-D optimization, one reference frame, variable block size ME, full-search ME algorithm, IPPP sequences, 30 frames/s (fps), CABAC entropy coder, quantization parameters (QPs) of 18, 23, 28, 33, and at 16. Note, the variable block size ME design adopts a tree-based computation, that is, the R-D cost of the larger block size is summed from the cost of the small block size. Thus, no extra memory bandwidth is required for the variable block size ME computation. Therefore, we will not include the memory bandwidth of different block sizes in the following results.

In the following simulations, we classify the corresponding bandwidth conditions into two patterns: constant data bandwidth(CDB) and variable data bandwidth (VDB). Both patterns provide the same amount of reference block data for the same search range . However, the CDB pattern will assume the available bandwidth is constant and fixed during ME operations, while the VDB pattern will assume the available bandwidth is variable during ME operations. Note that all the available data bandwidth will be consumed for the conventional

full search algorithm in JM, but not in our approach. The CDB pattern is the scenario used in the traditional ME design without considering other components, while the VDB pattern is to simulate the bandwidth changing scenario due to situations like simultaneous coding and decoding in a video phone or different power modes for mobile applications.



V. CONCLUSION

This paper has presented an efficient bandwidth-scalable ME design for bandwidth-limited mobile video coding. The bandwidth efficiency was co-optimized at the algorithm and architecture levels. Experimental results showed that the proposed

algorithm can utilize a bandwidth very close to the target system bandwidth, while its coding efficiency is similar to that in JM. As a result, the final design can provide superior power efficiency under CIF and D1 30-frames/s video coding as compared to the previous state-of-the-art designs. The presented approach can be combined with other low-power approaches to further reduce the overall power. Besides, further extending this approach to multiple reference frame ME is easy by considering the R-D gain for each reference frame into the bandwidth efficiency formula, which will be studied in our future work.

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