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# LOW POWER - HIGH EFFICIENT VIDEO ENCODING FOR IMAGE QUALITY IMPROVEMENT IN BATTERY-OPERATED SURVEILLANCE CAMERA

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## ABSTRACT

*Growing needs for surveillance in locations without power lines necessitates the development of a surveillance camera with extremely low power consumption and an assured stable operation until the time of expected run-out of available energy. The "sum of the absolute difference" has to be used to comparing the video frames, to identifying the different frame values to be encoding then to storing the memory. So this paper also reducing the memory space. The sum of the absolute difference will be act as a block search algorithm for varying the video quality a variable block search will be used. A novel architecture of maintaining the video quality of a surveillance camera even with low battery backup is proposed. A variable block search algorithm which has the capability to dynamically adapt the search window size according to external control is introduced. By searching speed of the variable block search algorithm is very high compared with fixed block search and the motion estimation quality is moderate. By varying the searching time of the variable block search algorithm, the Battery backup is reserved to wok a long time than usual. The performance evaluation of timing comparison for fixed block search algorithm and variable block search algorithm will be done using ALTRA QUARTUS II TOOL.*

***Keyword: DS- Diamond Search, HD- High Definition, ME- Motion Estimation, P-R-D Power-Rate-Distortion, SAD- Sum Of Absolute Difference Surveillance Camera, VBS-Variable Block Search,***

## I. INTRODUCTION

To meet the growing demands on public security against crimes, accidents, and disasters, it is necessary to enhance monitoring functions in places even without power lines, which, in turn, depends on the availability of battery-operated video camera with very low cost and power consumption. In such a battery-powered surveillance system, energy management becomes a very critical issue. The primary requirement of such surveillance system is to capture events of concern and inform the relevant personnel before the battery runs out. To extend the battery lifetime in the surveillance system until the battery replacement, it needs to be operated in an event-driven manner, i.e., the system captures events and encodes the images for storage and/or transmission when and only when the event is detected. However, duration and arrival time of an event is generally assumed to be uncertain. Such uncertainties make it difficult to predict actual video encoding time and to find the paretooptimal (with respect to energy, distortion, and rate, according to the system specification) video encoding configuration. Conventional methods based on worst-case scenario are likely to waste energy, because the estimation of event duration is too conservative, i.e., each event is assumed to have the longest possible value. In smart surveillance systems, video encoding configuration is selected among many encoding configurations with different distortion and energy consumption levels. In video encoding such as H.264 or MPEG4, the amount of distortion of a compressed video can be represented as a function of the amount of consumed energy when the bit rate is constant. In a power-scalable video encoding method is proposed to minimize the energy consumption in portable video communication devices.

Several methods have been proposed to maximize the overall performance under energy constraints.

## II. ENERGY MINIMIZATION OF PORTABLE VIDEO DEVICE

Multimedia has experienced massive growth in recent years due to improvements in algorithms and technology. An important underlying technology is video coding and in recent years, compression efficiency and complexity have also improved significantly. Applications of video coding have moved from set-top boxes to internet delivery and mobile communications. H.264/AVC is the latest video coding standard adopting variable block size, quarter-pixel accuracy, motion vector prediction and multi-reference frames for motion estimations. Thesis new features result in higher computation requirements than that for previous coding standards. In this thesis, we propose to maintain video quality in surveillance camera even with low battery backup.

Portable video communication devices operate on batteries with limited energy supply. However, video compression is computationally intensive and energy-demanding. Therefore, one of the central challenging issues in portable video communication system design is to minimize the energy consumption of video encoding so as to prolong the operational life time of portable video devices.

In this work, based on power-rate-distortion (P-R-D) optimization, we develop a new approach for energy minimization by exploring the energy tradeoff between video encoding and wireless communication and exploiting the non stationary characteristics of input video data. Both analytically and experimentally, we demonstrate that incorporating the third dimension of power consumption into conventional R-D analysis gives us one extra dimension of flexibility in resource allocation and allows us to achieve significant energy saving. Within the P-R-D analysis framework, power is tightly coupled with rate, enabling us to trade bits for joules and perform energy minimization through optimum bit allocation. We analyze the energy saving gain of P-R-D optimization by using Variable block search algorithm (VBS). We develop an adaptive scheme to estimate P-R-D model parameters and perform online resource allocation and energy optimization for real-time video encoding. Our experimental studies show that, for typical videos with non stationary scene statistics, using the proposed P-R-D optimization technology, the energy consumption of video encoding can be significantly reduced (by up to 50%), especially in delay-tolerant portable video communication applications.

There are three things to be chosen to develop motion estimation algorithm. They are Block matching algorithm, Search algorithm for motion estimation and Type of motion estimation algorithm.

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## III. TYPE OF MOTION ESTIMATION ALGORITHM

### 3.1 Fixed Block Size Motion Estimation

In the first generation coding standards, the block size is confined to 8 by 8 or 16 by 16. A large block size favors encoding of a uniform area whereas small block sizes favor detailed area encoding. Within a picture, detailed uniform areas coexist and fixed block sizes must sacrifice prediction quality to reduce complexity.

### 3.2 Variable Block Size Motion Estimation

In order to adaptively select a suitable block size for picture macroblocks, variable block size motion estimation has been added in the latest codec standards, e.g. H.264. In H.264, each picture (frame) is segmented into macroblocks. Each macroblocks is further divided into sub-blocks with 7 different types of block sizes (4x4, 4x8, 8x4, 8x8, 8x16, 16x8 and 16x16). Each macroblocks has in total 41 types of sub-blocks to cover the whole macroblocks. In variable block size motion estimation, for each type of subblocks, a motion vector is produced. In total 41 motion vectors are calculated per macroblocks. Variable block size motion estimation the signal to noise ratio is increased. So it is best suited motion estimation procedure.

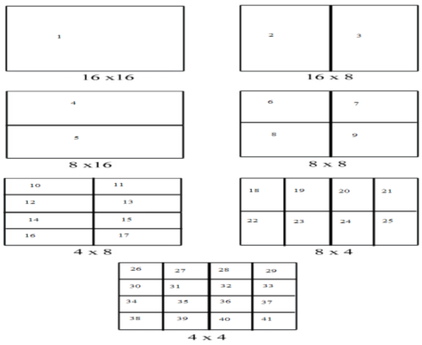


**Fig 1.Variable block sizes**

### 3.3 Reference and Current Frames

Each picture is segmented into macro blocks. Each macro block is further divided into sub-blocks with 7 different types of block sizes (4x4, 4x8, 8x4, 8x8, 8x16, 16x8 and 16x16). After motion estimation, a picture residue and a set of motion vectors are produced. The following procedure is executed for each block in the current frame.

1. For the reference frame, a search area is defined for each block in the current frame. The search area is typically sized at 2 to 3 times the macroblocks size (16x16). Using the fact that the motion between consecutive frames is statistically small, the search range is confined to this area. After the search process, a 'best" match will be found within the area. The 'best' matching usually means having lowest energy in the sum of residual formed by subtracting the candidate block in search region from the current block located in current frame. The process of finding best match block by block is called block-based motion estimation.

2. When the best match is found, the motion vectors and residues between the current block and reference block are computed. The process of getting the residues and motion vectors is known as motion compensation.

3. The residues and motion vectors of best match are encoded by the transform unit and entropy unit and transmitted to the decoder side.

4. At decoder side, the process is reversed to reconstruct the original picture.

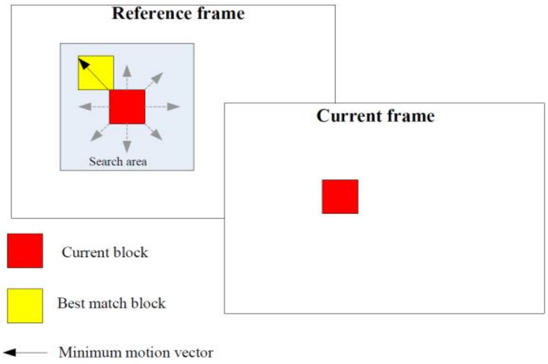


**Fig 2. Motion estimation**

## IV. BLOCK MATCHING ALGORITHM

### 4.1 Sum of Absolute Difference (SAD)

It is a widely used, extremely simple algorithm for measuring the similarity between image blocks. It works by taking the absolute_difference between each pixel in the original block and the corresponding pixel in the block being used for comparison. These differences are summed to create a simple metric of block similarity, the $L^1$ norm of the difference image. The sum of absolute differences may be used for a variety of purposes, such as object_recognition, the generation of disparity_maps for stereo images, and motion_estimation for video compression.

SAD algorithm is frequently used in motion estimation process.SAD algorithm is used for measuring similarities between the image frames. It is very efficient in hardware implementation, very fast and simple to calculate.

#### 4.1.1 Formula

$$SAD(x, y, r, s) = \sum_{j=0}^{15} SAD16_j(x, y, r, s)$$

Where SAD=sum of absolute difference. x, y, r, s are the block search parameters.

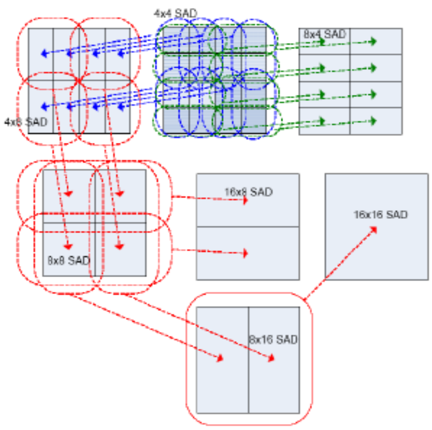


**Fig 3. SADs of Larger Sub-Blocks are Obtained by Summing up the SADs of Smaller Sub Blocks.**

*For example:*

| ***Template*** | ***Search image*** |
|---|---|
| *2 5 5* | *2 7 5 8 6* |
| *4 0 7* | *1 7 4 2 7* |
| *7 5 9* | *8 4 6 8 5* |

*Calculating the SAD values for each of these locations gives the following:*

| ***Left*** | ***Center*** | ***Right*** |
|---|---|---|
| *0 2 0* | *5 0 3* | *3 3 1* |
| *3 7 3* | *3 4 5* | *0 2 0* |
| *1 1 3* | *3 1 1* | *1 3 4* |

*SAD value are 20, 25 and 17*

Right side of the search image is the most similar to the template image, because it has the least difference as compared to the other locations.

**4.1.2 SAD Reuse Technique**

To maximize distortion data reuse, a new fast VBSME algorithm is proposed. The proposed fast variable block size motion estimation (FVBSME) algorithm unifies the motion search of different subblocks into a single motion search process. Full distortion data reuse is achieved and thus reduces computational complexity substantially. A novel stopping criterion and filled search pattern are used, which guarantee that all the 41 MVs are pointing to a local or global distortion minimum during convergence.

## V. BATTERY BASICS

A battery cell is characterized by the open-circuit potential (VOC), i.e. the initial potential of a fully charged cell under no-load conditions, and the cut-off potential (Vcut) at which the cell is considered discharged. Each cell consists of an anode, a cathode and the electrolyte that separates the two electrodes. The electrical current obtained from a cell results from electrochemical reactions occurring at the electrode-electrolyte interface. The two important effects that make battery performance sensitive to the discharge profile are (i) Rate Capacity effect, and (ii) Recovery effect.

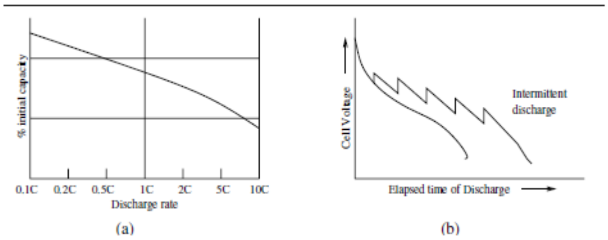


**Fig 4: Non Ideal-Battery Properties: (a) Rate Capacity Effect, (b) Recovery Effect**

The lifetime of a cell depends on the availability and reachability of active reaction sites in the cathode. When discharge current is low, the inactive sites (made inactive by previous cathode reactions) are distributed uniformly throughout the cathode. But, at higher discharge current, reductions occur at the outer surface of the cathode making the inner active sites inaccessible. Hence, the energy delivered (or the battery lifetime) decreases since many active sites in the cathode remain un-utilized when the battery is declared discharged. Concentration of the active species (charged ions of Lithium and Nickel) is uniform at electrode-electrolyte interface at zero current. As the intensity of the current is increased, the deviation of the concentration from the average becomes more significant and the state of charge as well as the cell voltage decrease. This phenomenon is called *R*ate Capacity effect. Figure shows the loss of capacity with increasing load current for a typical NiCd battery. The C rating is specified as the capacity for a given time of discharge.

## VI. SEARCH ALGORITHM

The faster approach is the block based motion estimation. The candidates frame is divided into non-overlapping blocks ( of size 16 × 16, or 8 × 8 or even 4 × 4 pixels in the recent standards) and for each such candidate block, the best motion vector is determined in the reference frame. Here, a single motion vector is computed for the entire block The search algorithms are full search and diamond search.

### 6.1 Diamond Search

Although the conventional FS algorithm achieves the best quality amongst various Motion Estimation (ME) algorithms and it is straightforward and has been successfully implemented on VLSI chips , its computational complexity is very high. In contrast, real time and portable multimedia devices require ultra computationally efficient video codec designs that will allow for a robust and reliable video quality. The proposed DS algorithm employs basically for a search pattern for easy prediction of motion vector present which is originally deviated from the frames, and it employ two search patterns. The first pattern, called large diamond search pattern (LDSP) shown in figure 5 (a), comprises nine checking points from which eight points surround the center one to compose a diamond shape. The second pattern consisting of five checking points forms a small diamond shape, called small diamond search pattern (SDSP) shown in figure 5 (b). In the searching procedure of the DS algorithm, LDSP is repeatedly used until the minimum block distortion (MBD) occurs at the center point. The search pattern is then switched from LDSP to SDSP when it reaches the final search stage. Among the five checking points in SDSP, the position yielding the minimum block distortion (MBD) provides the motion vector of the best matching block.

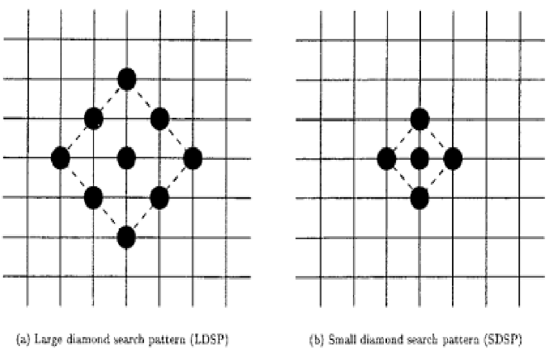


**Fig 5: (a) Large Diamond Search Pattern (b) Small Diamond Search Pattern.**

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## VII. RESULTS

### 7.1 Video To Image Frame Conversion

Block matching algorithm is a standard technique for determining the moving object in video. Blocks are formed in a region without overlapping on the other region. Every block in a frame is compared to the corresponding blocks in the sequence of frames and compares the smallest distance of pixel values. A MATLAB Implementation of Motion detection for an 64 frame video sequence is shown. The frame rate per second is measured as 25fps.

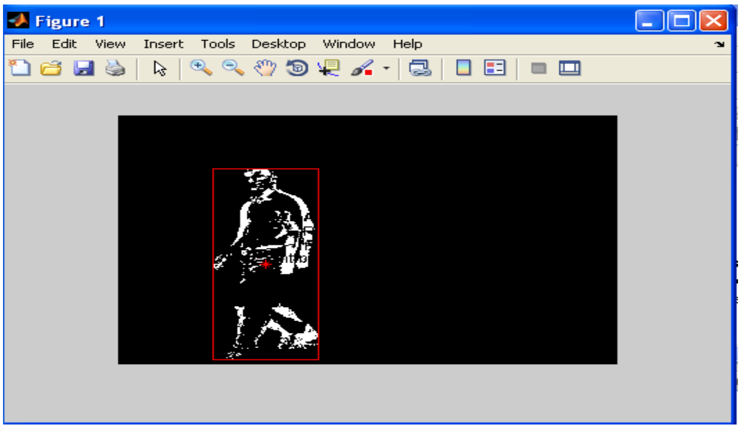


**Fig.6: Video to Image Conversion.**

### 7.2 Motion Vector

A Randomly generated image pixel value of size 255 bit is assumed as an 16*16 image array and processed with variable block motion estimation algorithm with the block window size varies from 2x2 to 16*16 based on the quality of video coding required. In future the quality aspect will be controlled through a battery source. A motion vector is the key element in the motion estimation process. It is used to represent a macroblock in a picture based on the position of this macroblock (or a similar one) in another picture. It is called the reference picture.

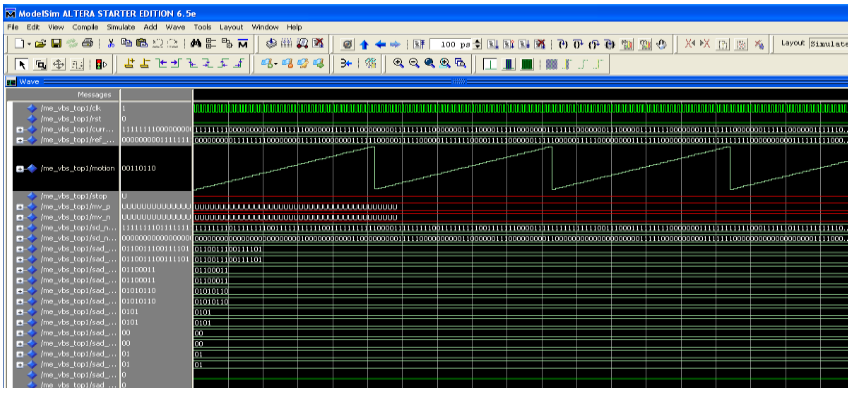


**Fig .7: Result for finding Motion vector by using variable block search algorithm.**

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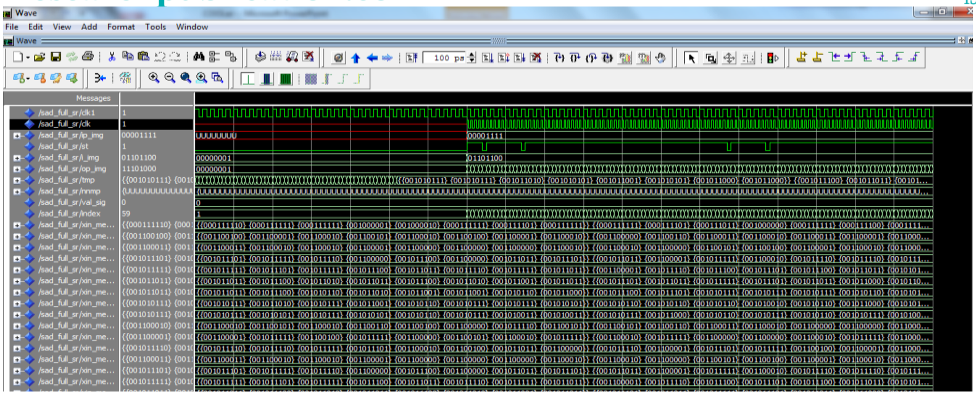
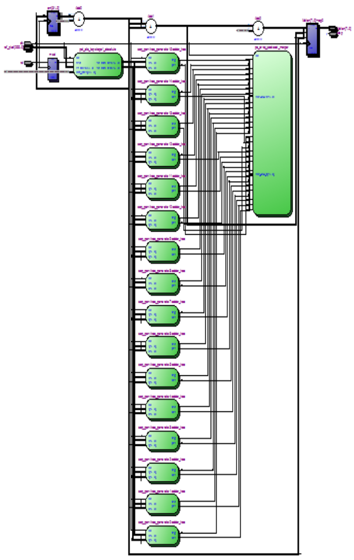


**Fig .8: Result for finding Motion vector by using fixed block search algorithm.**



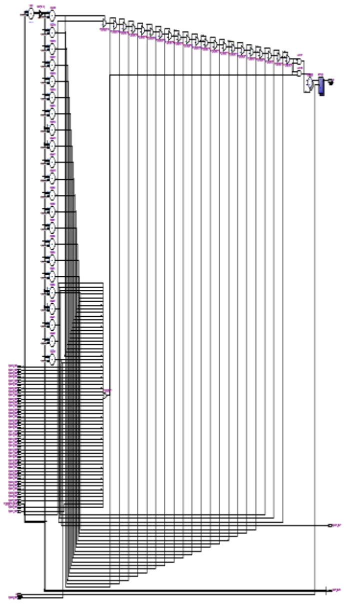


**Fig. 9: RTL Schematic for Full Search FBS.** **Fig. 10 RTL Schematic for full search VBS.**

## VIII. COMPARISON TABLE FOR FBS AND VBS POWER DISSIPATION:

| POWER DISSIPATION | FBS | VBS |
|---|---|---|
| TOTAL THERMAL POWER DISSIPATION | 656.67MW | 233.51MW |
| DYNAMIC THERMAL POWER DISSIPATION | 0.00MW | 0.00MW |
| STATIC THERMAL POWER DISSIPATION | 220.94MW | 176.63MW |
| I/O THERMAL POWER DISSIPATION | 435.73MW | 56.88MW |

## IX. CONCLUSION

Our algorithm proposals are suitable for low power devices ,low bit rate applications and designing consumer electronics product that require real time processing or compression at affordable price. Thus a successful implementation of utilizing the known Variable Block search Algorithm for maximizing battery backup lifetime is done using Modelsim simulator. The performance evaluation of existing fixed block motion search is compared with Variable block search algorithm and the Power analysis report of Quartus Synthesizer Tool suggests the betterment of VBS over FBS for implementing in Battery life time maximization.

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