Appraisal of motion estimation techniques in video compression

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Abstract. In this paper, plan to propose a new motion estimation technique similar to that of estimation methods such as full search 3ss, 4ss, block matching approaches and parametric motion estimation. Motion Estimation is mainly used to estimate the motion or error in an object. It can easily identify and tracks the movements of object in a frame. In this paper to present a detailed survey of motion estimation techniques and various methods of searching methodologies are also analyzed. Investigation shall also be carried out to estimate the motion to enrich the quality of decompressed video by analyzing the compression error. A study on not only the design of new motion estimation algorithm but also error free compression is going to be the main objective.

Keywords: Video compression, motion estimation, lossless compression, CNN.

1. Introduction:

In video sequences, the time constraints with high data rates that are common and very challenging one, because of it takes more space for storage and time taken for transmission. Now a day some techniques are implemented to solve these issues. Motion Estimation [ME] is one of the steps used in video compression. So many methods and techniques are achieved for estimation. Motion Estimation is one of the key sources of information for video compression. In arises due to moving objects like video sequences. In motion estimation process two successful frames are added/taken (current frame and reference frame), it is compared and then subtracted using the Block Matching Algorithm (BMA) and searching methodology like (full search, 3ss, 4ss, etc…..). Finally, the difference is calculated and then it is send along with the Motion Vector (MV). An accurate motion vector is very important to enrich the quality of video. Accurate motion vector is difficult to identify because of repetition pattern can occur and multiple similar local minima exist in the searching area so it is not easy to find the accuracy of motion estimation.

In a semi global motion estimation method is used for both the local and global characteristics of a repetition region. This semi-global approach is achieved for repetition pattern blocks, this method the repeated blocks can be merged then derive a single motion vector using the merged blocks. It estimates the motion vector of whole image. The accuracy of motion estimation is very high and the computational complexity is reduced by using this semi-global motion estimation of a repetition pattern region method.
2. Methods of Motion Estimation

In general, all have an intuitive understanding of the concept of motion estimation in video compression. This paper deserves the various methods of motion estimation and also to be classified in the case of digital video compression.

![Figure 1. Basic Idea of Motion Estimation Process Flow](image)

2.1. CNN-Based Motion Estimation

In [1] CNN, it is trained to identify two classes that is good match and another one is bad match like Figure 1. CNN calculates the probabilities and estimates the motion vectors using the similarity of a pair of images in a video sequence. The probability of good match is regarded as the resemblance of two blocks, and then calculates the motion vectors. To evaluate this method PSNR value has been increased by using the CNN. Therefore the CNN model (Figure 2) estimate the motion vector accurately compared with other existing motion estimation methods. Objective and subjective results both gives the outperformed results than the other methodologies.

2.2. Semi-Global Approach

In this approach [2], a repetition pattern region has been taken, it makes difficult to calculate an accurate motion vectors. Because in this search space region have multiple local minima so to derive an accurate motion vector is not an easy one. In order to improve the accuracy of motion estimation in repetition region, this Semi-Global approach consists of two steps.
Step 1: Makes a histogram of the motion vector candidates that are obtained during the motion estimation for individual blocks in the repetition region.

Step 2: Selects the most frequent moving vector candidate in the histogram to be the final motion vector of the entire repetition region.

Exhaustive full search based block matching is used to estimate the initial motion vectors and identify the repetition pattern blocks presented. The entire repetition region shares the same motion vector that is the representative motion vector of the region. Therefore the interpolated frame generates the corrected motion vector.

In [5], [2], Global Motion temporal filtering methods are used for an optimal filtering. Encoder assisted post filtering scheme is applying to this and higher order motion estimation is performed with a combination quality optimization method to find the optimal number of frames for filtering. Encoding of video sequence & Global Motion Estimation (GME) is performed parallel. Then the higher order motion estimation is detected. The same conditions to be performed for decoded frames. Finally reconstructed frame is compared with original using PSNR.

In [23], an efficient, robust and fast Global Motion Estimation method is used to estimate an image sequences in three stages.

2.2.2. Steps for Global Motion Estimation:

Step 1: A low pass image pyramid is built.

Step 2: A modified step searching method is used at the top of the pyramid and initial translation is estimated with full pixel precision.

Step 3: At each level of the pyramid, a gradient descent execution is starting from the initial translation at the coarsest level.
2.3. Variable Block Size Motion Estimation

Variable Block Size motion estimation method consists of three (upper, middle & lower levels) hierarchical levels between the search range of [-p, +p] it achieved a better accuracy. To determine a suitable block model according to the motion field distribution and correction within a macro block in [18] it also reduce amount of computational complexity at encoder perform well and achieves a significant speedup on the motion estimation both low motion sequences and high motion sequences.

Inter/Intra level classification and various data flows to analyze the impact of supporting VBSME in different between the architectures. Two hardware architectures were developed that can support fixed block size motion estimation as well as VBSME in [19]. Fewer reference pixels register a shorter critical path used in first between designs. Another one is to dimensional distortion array and one adder tree with the reference buffer that can maximize the data reuse between successive searching candidates. It can achieve of 99.9% off chip memory bandwidth and 99.22% of on-chip memory bandwidth.

2.4. Interpolation Based Motion Estimation

In this type of method using dual motion estimation is performed by using unidirectional & bidirectional matching ratios. It can evaluate the accuracy of motion vector and enchase the accuracy also improve the average of peak-signal-to-noise ratio of interpolated frames in [9][13].

Method of Interpolation technique is reduced cost compared to 6-tap filtering procedures, further produced reduction of the estimation time also achieved [6]. FME sub sample motion vector at low computational complexity [10]is discussed. It is capable of low computation complexity sub sample motion estimation without pixel interpolation. That is interpolation free motion estimation and it can achieve SP reduction. The FME algorithm substantially reduces computational complexity at the cost of negligible MSE method does not require any interpolation [13] & does not provides motion compensated frames also, it does not take more time but it detect motion vector accurately.

2.5. Pixel Based Motion Estimation

In [3], [13], [22], half pixel, sub pixel and fractional pixel is performed. Half pixel motion estimation gives more accurate motion estimation and performance is evaluated in H.263 frame work. It can improve video coding speed by reducing the computations up to 50% compared with the conventional half pixel full search method.

In [7] symmetric motion estimation (SME) is utilized. It uses a new pixel wise motion estimation for frame interpolation and use adaptive search pattern for the motion estimation. SME and BMA both are combined and to reduce the computational time of pixel wise motion estimation. It performance is well and achieve better quality.

2.6. Searching Methodology

In motion estimation process, searching pattern plays an important role and it search some region in a blocks of image like Diamond, 3SS, 4SS, Full Search, etc. It used to detect the similarities between the frames and it transmitted in the form of motion vector [17]. It uses predicted location and to detect the local minimum JM 9.0 modified is used for this search pattern. Adaptive Search Range(ASR) and Heuristic Search Pattern(HSP) to be combined in [14], the search range is changed adaptively and the results in the search window [SW] correspondingly shrunk, then HSP imposed inside the shrunk search window. It can reduce computational speed up about 23% compared with full search.
2.7. Evaluation of Motion Estimation

UMHexgons algorithm has been adopted and it can reduce time consuming on encoding process of motion estimation.

2.7.1. Search Pattern Used for UMHexgons Method:

(i) Irregular cross search pattern,
(ii) New square pattern
(iii) Multi-Octagon-Grid search
(iv) Horizontal & Vertical Hexagon search methodologies.

It achieves performance from 1.06% to 17.31% with maintaining better image quality [8].

In [24] different block matching algorithms & performance are evaluated and also compared together in terms of PSNR. Some searching methodologies are (i) Full Search Strategy (Figure 3) (ii) 4SS strategy (iii) Diamond search (iv) Adaptive rood pattern search strategy [ARPS]. In this, algorithms were compared and PSNR value is calculated. ARPS give best PSNR & minimum errors will be given. ARPS algorithm is best one to implement & save time compared with other three methods.

2.8. Other Motion Estimation Methodologies

The defect of human vision has been exploited in [4] to enrich the quality & reduce the search range of the video sequences. The frame rate is greater than 16 frames/second goes unnoticed by human eyes, exploiting this fact we can reduce the number of search points in the frame. First frame is taken as the ‘I’ frame and calculate the motion vector first then the Binary search is performed. The principle of persistence of vision, the human eyes did not detect & need not make the separate entries in the database. Therefore we are able to reduce the number of entries in the database thereby reducing the number of computation.

![Figure 3. Full Search Motion Estimation](image-url)
Wavelet based optimal motion estimation increase the performances as well as the coding gain of a complete video sequence but the cost of an argument complexity [15]. It first of all uses the motion estimation criterion to find motion vector in two sequences. Then compare motion vectors and obtain sum of absolute difference (SAD) or sum of squared differences (SSD).

Multi-Frame motion estimation provides motion trajectories that are more accurate as well as faster than the Full search BMA (see Table 1). The (Maximum a Posterior) MAP estimation exploits the temporal correction between motion fields. It model motion fields with three dimensional (3-D) Gibbs distributions[11].Another one method is fast multiple reference frame motion estimation. It used SAD, SATD, or SSD to detect the all zero case. SKIP mode is often selected as the best MB mode. If motion vectors of large blocks are very similar, also very different from those of smaller blocks. This algorithm is more helpful for highly textured areas. It can save 30% - 80% of motion estimation computation [16]. It can be easily combined and achieved better performance.

Four real transforms (FT) (FFT) (DCT) (DCT11) [20]to be combined to obtain a new complex linear phase transform by using DCT- based phase correlation motion estimation algorithm. FFT-based phase correlation motion estimation is difficult to identify motion but it is not so efficient for video compression. All this four methods transforms are performed based on transform domain motion estimation. It reduce the computational complexity compared to the previous works.

**Comparative Study**

According to the methods discussed above, the performances of different methods have been compared on various parameters.

| S.No. | Proposed Methods                  | Performance Gain            | Percentage Gain | Compared Methods                  |
|-------|----------------------------------|-----------------------------|-----------------|-----------------------------------|
| 1.    | Variable Block Size Motion       | Memory bandwidth            | 99.9 %          | Other Search Patterns             |
|       | Estimation                       | off-chip - On-chip          | 99.2 %          |                                   |
| 2.    | Half Pixel ME                    | Computation                 | Up to 50 %      | Half Pixel Full Search            |
| 3.    | ASR & HSP                        | Computation Speed           | 23 %            | Full Search                       |
| 4.    | UMHexagons                       | Performance improved        | 1.06 % to 17.31%| Other ME Techniques               |
| 5.    | Defect of Human Vision           | PSNR Improved               | 8.72 %          | Other Methods                     |
|       |                                  | Computation Reduced         | 9.86 %          |                                   |
| 6.    | Multiple Reference Frames        | Save Computation            | 30 % to 80 %    | Other Conventional Fast Algorithm |
3. Conclusion

This paper presents a detailed overview on various methods of Motion estimation techniques to support the reduction of local minimum and easily identify the motion vectors. All the above methods are analyzed for their performance in motion estimation and compared with other techniques. According to the analysis, the methods have different implications in different situations. This survey satisfies analysis of all blocks of an images in the past, which strongly helps the authors currently working in this domain. They can effectively choose their problem domain from the discussion.

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