

An Overview of Motion Estimation Algorithms

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Abstract: *With emergence of new technologies for enhancing user experience such as 3-D television results in larger amount of video data to be processed and transmitted. Video compression is likely to be an essential component of video processing for many years to come as bandwidth of today's network is limited. It is well known that in the coding pipeline, motion estimation and motion compensation are most important and time consuming components. There is need of efficient coding and decoding with development of new range of real time applications. In this paper we have presented overview of various motion estimation algorithms.*

Keywords: Block Distortion Measure, Motion compensation, Motion Estimation, Video Coding

1. Introduction

Visual information is vital for new communication media with recent advances in technology. There is exponential growth in digital telecommunication industry and keep on evolving pushed by fundamental applications and some new applications such as videoconferencing, video e-mail, next generation mobile phones, and video streaming over personal digital assistants. Video signals demand a huge amount of information compared to audio or texts. Video storage and transmission require the use of compression despite the increasing disks storage capacity and the development of broadband networks.

The bandwidth available for digital television is in the order of 40 Mbps with cable & terrestrial broadcast system and 60 Mbps with a satellite channel which are clearly less than the bit rate requirement of 162 Mbps using 4:2:0 digitization format. Similarly the bit rate available with a connection through the all-digital ISDN is between 64 Kbps and 2 Mbps. The bandwidth requirement of video conferencing is 81 Mbps with CIF, for Video telephony it is 40.5 Mbps with QCIF which are far excess. Hence in order to provide such services over related networks it is necessary to reduce the bandwidth requirement of source digital using compression and also considerable cost saving can be made[1].

Motion Estimation Problem

Motion estimation and compensation techniques have shown their efficiency to reduce temporal redundancies in video coding applications. Motion estimation analyzes the movement of objects in the scene. The resulting motion information allows to improve interframe predictive coding. The main idea behind block matching estimation is the partitioning of the target (predicted) frame into square blocks of pixels and finding the best match for these blocks in a current (anchor) frame. To find the best match, a search inside a previously coded frame is performed and the matching criterion is utilized on the candidate matching blocks. The displacement between the block in the predictor frame and the best match in the anchor frame defines a motion vector. On the one hand, motion estimation algorithms should provide suitable prediction information, and while on the other hand, they should have low overhead information[2].

2. Overview of Existing Algorithms

Two fast motion estimation algorithms were proposed in 1992 by A.Zaccarin, B.Liu[3] using pixel and block subsampling to reduce computational complexity. The proposed technique was robust as full search was employed to estimate the fraction of motion vectors. The effect of aliasing was minimized by alternating pixel subsampling patterns with searched locations. By a factor of 4, each block and pixel subsampling reduced the computational complexity of block motion estimation by a factor of 16. The proposed algorithm required an overhead of 0.016 bits per pixel compared to TSS.

A new adaptive motion tracking search algorithm (AMT) was proposed in 1999 by J.Xu, L.Po and C.Cheung [4] based on spatial inter block motion field correlation. To predict initial search center, the algorithm exploited inter block correlation. The algorithm used center biased block matching algorithm to refine the final motion vector. Experimentally it was observed that mean biased prediction AMT search algorithm in combination with N3SS and 4SS effectively improved the performance. The search point average varied from 18.7 to 18.90 for „tennis“ sequence and from 17.71 to 17.73 for „football“ sequence. In 2004, A. Barjatya[5] reviewed the block matching algorithms used for motion estimation in video compression. The algorithms that described were Exhaustive Search (ES), Three Step Search (TSS), New Three Step Search (NTSS), Simple and Efficient TSS (SES), Four Step Search (4SS), Diamond Search (DS), and Adaptive Rood Pattern Search (ARPS). The motion compensation based video compression was first described in brief. Then 7 of the most popular block matching algorithms were illustrated and simulated, with their comparative study at the end.

Fast motion estimation using modified diamond search patterns by H. So, J. Kim, W. Cho and Y. Kim[6] was proposed in 2005. This algorithm utilized the directions and magnitudes of motion vectors between inter blocks and used a smaller number of search points and restricted search area than conventional diamond search patterns. Algorithm was mostly suitable for high degree of motion when speed and computation had priority. For slow, medium and fast motion sequences, modified diamond search was found to be faster by 15%, 19% and 45% respectively compared to other

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method. The two different cross-diamond-hexagon search algorithms (CDHS-F, CDHS-T) were proposed in 2005 by C. Cheung, L. Po [7]. These two algorithms differ from each other by their sizes of hexagonal search pattern. Basically two cross shaped search pattern was employed by these algorithms consecutively in the very beginning step and switch was performed using diamond shape pattern. Two pairs of hexagonal search pattern were proposed in conjunction with candidates found located at diamond pattern to further reduce the checking points. Experimentally it was found that proposed algorithm performed faster by about 144% and by about 73% than diamond search algorithm and cross diamond search algorithm respectively with maintaining similar prediction quality.

The original enhanced hexagonal based search (EHS) was used to speed up original hexagon based search by exploiting group distortion information of some evaluated points. The proposed EHS2 in 2006 by L. Po, C. Ting and K. Ng [8] with new point oriented inner search technique further speeded up hexagon based search in both small and large motion contents. The modified EHS2 was found faster than HS up to 34% with negligible PSNR degradation. In the work, based on the analyzed statistics of inner area new grouping principles were proposed. Mean interval distance was used as measurement to find correlation between inner points and coarse points. Experimentally it was found that EHS2 significantly reduced computation in the range of 15%-34% over original hexagonal search.

A Fully adaptive distance dependent threshold search (FADTS) by G. Sorwar, M. Murshed and L. Dooley [9] was proposed in 2007 for motion estimation. The automatic adaptation of threshold was achieved using desired target and the content from the actual video sequence to achieve either a guaranteed level of quality or processing complexity. In this algorithm only linear threshold function was considered. The algorithm achieved PSNR of 49.18dB for „football“ sequence. The algorithm had achieved all target with +/-1% of disagreement.

Multi directional gradient descent search algorithm (MDGDS) was proposed in 2008 by L. Po, K. Ng, K. Wong and K. Cheung [10] with the use of multiple one-at-time search in eight direction. The global minimum could be traced easily by performing eight one-dimensional gradient descent searches on error surface. The proposed algorithm showed significant improvement in computation reduction compared to well-known fast block motion estimation algorithms. It was observed that proposed algorithm was robust as it was able to work well with videos with different motion content.

The search pattern switching algorithm (SPS) by K. Ng, L. Po, K. Wong, C. Ting, and K. Cheung [11] was proposed in 2009 using a classifier, error descent rate. The classifier classifies the motion content of block. The proposed classifier requires few searching points in the search window. After classification process either the center biased motion estimation algorithm like block based gradient descent search/diamond search can be applied or coarse fine search algorithm such as 2D-log search /TSS can be applied. EDR

was found good estimator of distance between the global minimum and search window center. The estimation accuracy ranged from 76.03% to 98.80%.

To enhance cross octagonal search algorithm, Z. Cui, D. Wang, G. Jiang and C. Wu [12] in 2009 (COSA) proposed an adaptive threshold for early termination. The important factors impacting on searching speed and distortion performance of motion estimation algorithm is search pattern. COSA achieves the almost same visual quality with full search algorithm and takes fewer search points compared with hybrid unsymmetrical cross multi-hexagon grid. To avoid meaningless calculation after the searching speed was good enough an adaptive threshold for early termination of COSA was inducted. The experimental results showed that the proposed method reduced the motion estimation time compared to UMHexagonS with different types of sequences with negligible coding loss. It was found that the proposed algorithm performed better for fast moving sequences.

Joint adaptive block matching algorithm (JABMS) was proposed in 2009 by V. Ananthashayana, M. Pushpa [13] to find best match macroblock and to generate motion vector by classifying the image movement based on prediction error. When motion was small, the diamond search generated high estimation accuracy and large motions were handled by adaptive rood pattern search. For small, medium and large motions, the JABMS generated motion vector with improved motion estimation accuracy. For the proposed algorithm the PSNR was very close to full search algorithm, 0.0408 dB improvement over diamond search algorithm and 0.0573dB improvement over ARPS. Computation cost was reduced by 15.2 times compared to full search. 1.3 times compared to diamond search and increased by 0.6 times compared to adaptive rood pattern search method.

A novel directional gradient descent search algorithm, DGDS, using multiple OTS and gradient descent searches was proposed in 2009 by L. Po, K. Ng, K. Cheung, K. Wong, Y. Uddin, and C. Ting [14]. The minima found in the eight direction forms the basis for search point pattern in each stage. To improve the speed a fast version of DGDS was also proposed. For „Stefan“ sequence the PSNR found using DGDS was 0.338dB higher than BGDGS.

The search algorithm circular 2D log was proposed in 2010 by S. Ahluwalia, S. Rungta and A. Shukla [15]. The search area was continuously reduced by factor of 2 each time, search for best motion vector took up a new direction with number of points to be searched for each iteration decreased continuously than first iteration. The proposed algorithm had speed gain of more than 30% over the diamond search.

A novel reduced diamond search algorithm, RDS, by A. Harshad, R. Sadek and S. Mandour [16] was proposed in 2010. The fast block based motion estimation was based on center biased motion vector characteristics. Based on types of motion the proposed algorithm reduced average search points in the range of 20% to 60%. To speed up the motion estimation time and computation reduction, a threshold was used. By using threshold there was reduction of search points in the range of 10%-30%. For stationary blocks reduced

diamond search checks only 5 points. Reduced diamond search with the use of threshold was found beneficial for slow and medium motion.

In the proposed technique,(FCFS) by Z.Ahmed, A.Hussain and D.Al-Jumeily[17], when current calculated SAD value is greater than previous calculated one, for the full search algorithm, the calculation of SAD between pixels in the current block and pixels in the reference block will be stopped. The classification of fast block matching algorithms was described. Proposed technique in 2011, reduced computational time. Experimentally it was observed 27% improvement in computational time compared to full search algorithm.

The fast search algorithm rely on the assumption that the matching error decreases monotonically as the searched point moves closer to global optimum, however genetic algorithm is not limited to this restriction. The proposed algorithm (GAHX) in 2014,by C.Kung,W.Cheng and J.Jeng[18] used hexagon based search pattern and genetic algorithm. Experimentally it was found that the proposed algorithm performed well for video sequences with objects changing violently. However the proposed algorithm was not suitable for slow video sequences.

3. Conclusion

In this paper the literature survey for motion estimation algorithms was performed. Motion estimation and compensation have shown their need for improvement as it consumes 70% time of compression. There is high scope for improvement for motion estimation.

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