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Literature Review on Block Matching Motion Estimation Algorithms for Video Compression

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Abstract—**Motion estimation (ME) is one among the foremost computational intensive operations in video compression. It simply account for over 80% of the computation in an MPEG-2 video encoder. Efficient motion estimation reduces the energy within the motion-compensated residual frame and can dramatically improve compression performance. In this paper literature survey of motion estimation especially block matching motion estimation is performed. This paper also compares the existing block matching algorithms and gives their drawbacks. The applications of each algorithm are also discussed. The comparison is performed between the Exhaustive search (ES), Three Step Search (TSS), New Three Step Search (NTSS), Four Step Search (4SS), Diamond Search (DS), Hexagon-Diamond Search (HDS), Modified Diamond Search (MDS), Fast Diamond Search (FDS) and Orthogonal-Diamond Search (ODS).**

Index Terms— **Block matching motion estimation, DS, ES, NTSS, TSS, 4SS.**

I. INTRODUCTION

The idea behind video compression based on motion estimation is to save number of bits required for encoding the video. The purpose for doing motion estimation is to reduce the energy and bandwidth requirement for transmission of videos over wireless medium. Hence, this field has seen the highest research interest in the past two decades [1].

In videos, changes between the frames are mainly due to the movement of objects in the frames. Using a model for the motion of objects between the frames, the working of video encoder is to estimate the motion that occurred between the reference frame and the current frame. This process is termed as motion estimation (ME) [2]. The encoder then makes use of this motion model and the information to move the contents of the reference frame to generate a better prediction for the current frame. This process is called as motion compensation (MC), and the prediction that is produced by it is called the motion-compensated prediction (MCP) or the displaced-frame (DF) [3].

Several algorithms are developed for motion estimation by totally different researchers. Usually, 2 varieties are principally mentioned within the search types of motion estimation. They are: 1) pixel based motion estimation 2) Block based motion estimation. However block-based motion estimation is often most popular due to its simplicity and good compromise between prediction quality and motion computations [4].

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A. BLOCK MATCHING TECHNIQUE

Block based motion estimation is widely utilized in video compression for exploiting video temporal redundancy. Nonetheless, speeding up of the method is a major constraint. Therefore, large number of fast block matching algorithms (BMAs) has been anticipated for motion estimation by limiting the number of search locations. Additionally, simplifying the measure of match between two blocks under comparison is also possible [5].

Figure 1 illustrates a method of block-matching rule. In a very typical block matching rule, every frame is split into blocks, every of that consists of luminance and chrominance blocks. Usually, for coding efficiency, motion estimation is performed solely on the luminance block. Every luminance block within the present frame is matched against candidate blocks in a search space on the reference frame. These candidate blocks are simply the displaced versions of original block. The most effective candidate block is found and its displacement (motion vector) is recorded. In a very typical inter frame coder; the input frame is subtracted from the prediction of the reference frame. Consequently the motion vector and therefore the resulting error may be transmitted rather than the original luminance block; therefore inter frame redundancy is removed and data compression is achieved. At receiver end, the decoder builds the frame difference signal from the received data and adds it to their constructed reference frames [6, 7].

The well-known full search (FS) [8] is the simplest, however the foremost computation intensive algorithm. There are several computational effective block motion estimation algorithms that are proposed within the literature however with trade-off between the algorithm accuracy and algorithm speed. Three common matching criteria [9] used for block-based motion estimation are as follows-

- Mean of squared error (MSE)
- Sum of absolute difference (SAD)
- Matching pixel count (MPC)

The paper is organized as follows. Section 2 does the literature survey of various block matching motion estimation techniques. Section 3 compares the reviewed algorithms. Conclusion is made in Section 4.

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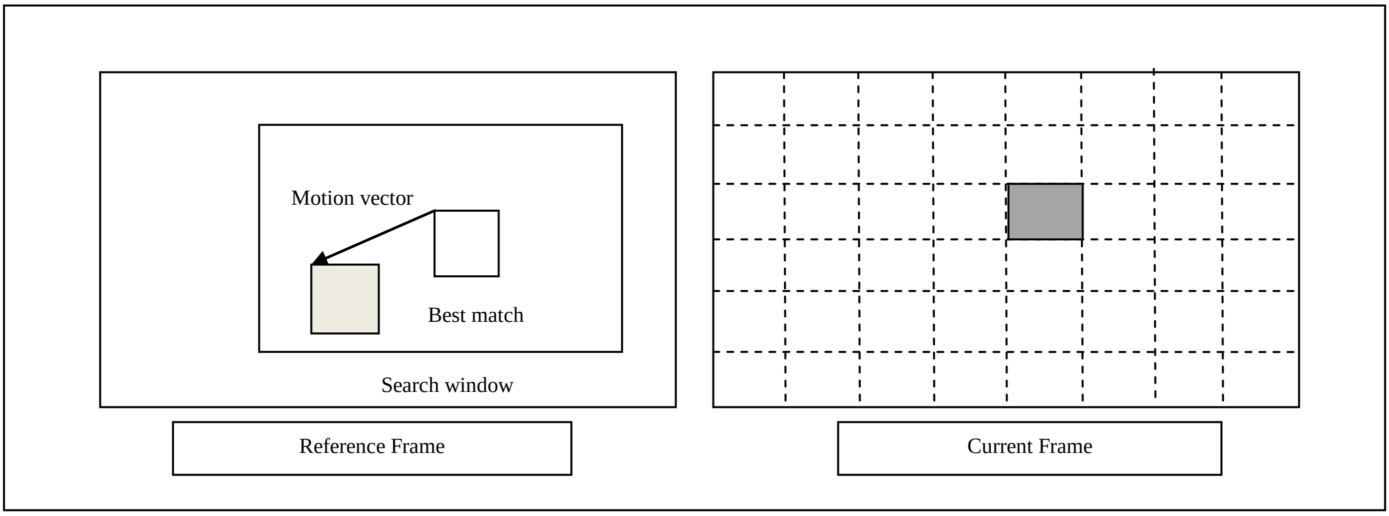

Figure 1: Block-matching Motion estimation

II. REVIEW OF LITERATURE

The extensive literature collected associated with the video compression system using block based motion estimation techniques is critically reviewed and given during this section.

The idea regarding completely different techniques available for video compression is mentioned in [10] (Rajeshwar Dass et al., 2012), [11] (S. Ponlatha et al., 2013), [12] (MuzhirShaban Al-Ani et al., 2011) and [13](Ajay et al., 2014). In these papers MPEG video compression standards are explained and also the idea of Inter-frame coding is mentioned that uses one or a lot of preceding and/or succeeding frames during a sequence, to compress the contents of the current frame. In [11] (S. Ponlatha et al., 2013) comparison of MPEG 1, MPEG 2 and MPEG 4 is additionally performed. Finally new techniques and technology, and a few new formats within the horizon also are mentioned in these review papers.

[14] (P.C.Shenolikar et al., 2009) discusses the various approaches for motion estimation. in this paper author has classified the motion estimation techniques as DCT based and wavelet based. DCT based motion estimation has low computational complexity however wavelet based coding has higher performance than ancient DCT based coding. This paper additionally compares the full Search and Three Step Search on the premise of PSNR and computations.

In [15] (Darun Kesrarat et al., 2010) the author explained the thought of motion estimation in two completely different classifications: one supported block-matching and the other supported optical flow. The algorithms were separated into three completely different groups, one is block-based algorithm that begin the method by large pattern of computation on block position such; TSS, TDL, CS, and NTSS. The second group is block-based algorithm however it begin the method from small movable pattern of computation on block position such; NFFS, BBGDS, HS, and NDS. And also the last group is optical flow algorithm that it focuses solely on the accuracy in MAE & PSNR. of course that the accuracy result in MAE & PSNR, the algorithm of optical flow is more than block-based however consume rather more computation time.

[16] (S Sangeeta Mishra et al., 2014) does the comparative study of block matching algorithms used for motion estimation in video compression. The algorithms are tested on the video sequences like "Container", "Boat" and "Tennis". The analysis relies on the MSE (Mean Square Error), PSNR (Peak Signal to Noise Ratio) and searching point per macro block. The analysis show that DS algorithm takes fewer numbers of search point and it's quicker.

[17] (S. Immanuel Alex Pandian et al., 2011) gives an overview of Block matching motion estimation algorithms in video coding. within the overview numerous block matching algorithms that vary from the very basic Full Search to the recent fast adaptive algorithms like Pattern based Search are mentioned.

Paper [18] (Shaifali Madan Arora et al., 2014) and [19] (Hussain Ahmed Choudhury et al., 2013) compares the fast block matching motion estimation algorithms. In [18] (Shaifali Madan Arora et al., 2014) comparison is performed based on the slow, moderate and fast motion activity in consecutive frames. The test sequences considered for every kind of motion activity are Akiyo and container sequences for slow motion, Foreman and car Phone sequences for medium motion and Flower and car Phone for fast motion. For slow motion sequences DS algorithm provides very best quality i.e. it has maximum PSNR however the amount of computations per frame and therefore the time needed is lesser. For medium motion sequences NTSS provides maximum PSNR and additionally the time needed to search out motion vectors is less. For fast motion sequences PSNR reduces drastically with fixed block size based techniques and tss provides best results in terms of PSNR.

In [20](Maria Santamaria et al., 2012), block matching algorithms are relatively studied by taking three completely different block sizes 8x8, 16x16 and 32x32. The potency of a BMA is decided by the amount of explored blocks (EXB). The quality of prediction of a BMA is calculated using the peak signal-to-noise (PSNR) and also the Structural Similarity Index (SSIM). The implementation was done using C++ programing language. According to the authors analysis very best quality of prediction was obtained using block size of 8x8 pixels.

Paper [21] (Jigar Ratnottar et al., 2012) does the review towards fast block matching algorithm for video motion

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estimation. In this paper author has developed algorithm to observe a moving object that's moving from a horizontal direction or a vertical direction, as long as the targeted object emerged totally inside the camera view range.

[22] (S.R. Subramanya et al., 2004) presents the results of performance analysis of combinations of many normally used block-based motion estimation algorithms and distortion measures. The motion estimation algorithms considered during this paper are (a) four-step search, (b) diamond search, (c) hexagon-based search, (d) optimized diamond search, and (e) optimized hexagon-based search. The distortion measures considered are (a) Mean squared Error (MSE), (b) Mean Absolute Error (MAE), (c) Mean Absolute Difference (MAD), and (d) Pixel Difference Correlation (PDC). The results facilitate selection of a specific combination of parameters for a given application under a group of constraints.

[23] (K. R. Namaduri et al., 2001) investigates recently developed motion estimation algorithms and presents the computational, and performance trade-offs involved in selecting a motion estimation algorithm for video coding applications. This paper conjointly investigates the consequences of the monotonic error surface assumption as well as the appropriate selection of initial motion vectors that leads to higher performance of the motion estimation algorithms. It specifically focuses on diamond search algorithm and study the performance trade-offs related to this algorithm.

In paper [24] (Fenta Adnew Mogus et al., 2010) the comparative performance of six totally different block matching algorithms are conferred and compared based on the parameters of Peak Signal Noise ratio (PSNR), Mean Absolute difference (MAD) and Search Points per Macro block.

In paper [25] (Angela D' Angelo et al., 2010) a technique for understanding the effectiveness of motion estimation techniques is conferred. Unlike other performance evaluation systems that are support the errors between the actual and also the predicted displacements the proposed technique is inspired to the Human visual system. The perceptual impact of geometric distortions induced by non accurate motion estimation is taken into account by means of an objective measure of the perceived distortion impact. The obtained results show that the scores obtained with the tested metrics usually don't match with the perceived quality, whereas the proposed methodology does. Therefore, the conferred tool will be utilized in the design and in the verification of a generic motion estimation algorithm

In paper [26] (Shan Zhu et al., 2000) author has proposed a brand new diamond search (DS) algorithm for fast block-matching motion estimation (BMME). The proposed DS algorithm employs two search patterns. The primary pattern is termed large diamond search pattern (LDSP). The second pattern consisting of five checking points forms a smaller diamond shape, referred to as small diamond search pattern (SDSP). Simulation results demonstrate that the proposed DS algorithm greatly outperforms the well-known three-step search (TSS) algorithm. Compared with the new three-step search (NTSS) algorithm, the DS algorithm achieves close performance however needs less computation by up to 22% on the average. Experimental results conjointly show that the DS algorithm is better than recently proposed four-step search (4SS) and block-based gradient descent search (BBGDS), in terms of mean-square error performance and needed number of search points.

[27] (Xuan-Quang Banh et al., 2005) proposes two improved algorithms, cited as Dual- Cross Search (DCS) and adaptive Dual-Cross Search (ADCS), to handle the constraints of the prevailing fast BMAs. The distinction between the two proposed methods primarily lies in how value price for early terminating the search of optimal motion vector is set. Because the names recommend, DCS uses a fixed-value threshold, whereas ADCS uses adaptive threshold in native video content.

In paper [28] (Yasser Ismail et al., 2009) a modified Diamond Search (MDS) algorithm is proposed for fast motion estimation based on the accepted Diamond Search (DS) algorithm. The proposed MDS algorithm uses a mixed flavor approach of Dynamic Internal Stop Search (DISS) and Dynamic External Stop Search (DESS). Additionally, early search termination and adaptive pattern selections techniques are applied to the proposed MDS as initialization steps to attain even higher complexity reduction.

The proposed algorithms in paper [29] (Xuan-Quang Banh et al., 2004) are improvement of existing BMAs and contains three effective steps: 1) Initial search center prediction, 2) Early search termination, and 3) dual-cross pattern search. extensive simulation results and comparative analysis have shown that the proposed algorithms outperform standard algorithms, like the three-step search, orthogonal search and diamond search, as well as the newly proposed algorithms, like the hexagonal search and adaptive rood pattern search, in terms of both video peak signal-to-noise ratio and also the number of checking points evaluated.

In paper [30] (Atalla I.Hashad et al., 2010) novel Reduced Diamond Search (RDS) algorithm for fast block matching motion estimation has been proposed. It is based on the center-biased characteristic of motion vector. Simulation results demonstrate that the proposed algorithmic rule reduces average search points by 20% to 60% according to different motion types with almost the same visual quality compared with other accepted block matching algorithms. A threshold to early terminate the block matching method is employed to speed up motion estimation time and computation reduction. Simulation results conjointly show that it reduces about 10% to 30% less in search points according to different motion types, with a very low degradation in video quality.

III. COMPARISON

Here the performance of reviewed algorithms is compared supported the results printed in various research papers. These papers used test video sequence of akiyo for the simulation. This video has slow and low motion activity. The comparative review is summarized in Table I.

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Table I. The performances of HDS, MDS, FDS and ODS are compared with DS algorithm [12], [13], [14], [18], [19], [20], [31], [32]

Year	Algorithm	PSNR (db)	Average search points	Application	Drawback
Benchmark	Exhaustive search (ES)	43.03	177.72	To obtain best picture quality and highest PSNR	High computational time (slow).
1981	Three Step Search (TSS)	44,94	20.68	recommended in MPEG2	Allocation of the check point at the first stage leaves several gaps which becomes inefficient small motion estimation.
1994	New Three Step Search (NTSS)	42.94	14.14	More efficient then TSS for small motion	It is designed especially for fixed block size. A slightly drop in MAE & PSNR and more complexity in step logic when compare with TSS due to many block patterns are taken in consideration under different MD point.
1996	Four Step Search (4SS)	42.94	13.14	Initial small step size so more efficient for small MV	Allocation of the check point may lead to wrong direction of MV if there are using to compensate over very fast movement sequence and more complexity in step logic due to many block patterns are taken in consideration under different MD point like NTSS.
2000	Diamond Search (DS)	42.90	11.06	adopted and incorporated in MPEG-4 verification model	1) it does not exploit the motion correlation between adjacent frames or blocks; 2) it exhaustively evaluates all eight neighboring points around the diamond center; 3) it cannot stop the search early even when the SAD at a particular checking point is already small enough,
2010	Hexagon-Diamond Search (HDS)	42.90	11.02	video conferencing over wireless networks	For vigorous motion content HDS provides slight degradation in video quality around 9.9%, when compared to NTSS algorithm and FS algorithm.
2011	Modified Diamond Search (MDS)	42.90	5.33	video sequences with simple and slow motion vectors	It may also be trapped in local minima.
2012	Fast Diamond Search (FDS)	42.95	12.82	implemented in the reference software of the standard H.264	Degradation in the coding efficiency compared to the conventional FS and DS.
2014	Orthogonal-Diamond Search (ODS)	42.90	10.01	Video sequences with slow motion vectors.	Slight degradation in quality for moderate and fast motion sequences compared to the small motion sequence.

IV. CONCLUSION

After review process it has been found that DS algorithm gives performance closer to the ES algorithm at minimum number of search points. Also the different variants of DS algorithms are also giving good results at an acceptable degradation in image quality. Hence the speed of these block based motion estimation algorithms can be improved by reducing number of search point and by using early termination process.

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REFERENCES

[1] T. Sravanthi, "An Adaptive Algorithm for Video Compression", International Journal of Emerging Technology and Advanced Engineering, Volume 2, Issue 12, pp. 335-340, December 2012.

[2] Deepa Mary Thomas, and Subha Varier, "A Novel Based Approach for Finding Motion Estimation in Video Compression", International Journal of Advanced Research in Computer and Communication Engineering, Vol. 1, Issue 8, pp. 514-521, October 2012.

[3] S.M.Kulkarni, D.S.Bormane, and S.L.Nalbalwar , "Coding of Video Sequences using Block Matching Motion Estimation Three Step Search Algorithms", International Journal of Innovative Research in Electrical, Electronics, Instrumentation And Control Engineering, Vol. 2, Issue 6, pp. 1651-1655, June 2014.

[4] Ionut Pirnog, Cristian Anghel, Andrei Alexandru Enescu, and Constantin Paleologu, "Evaluation of Fast Algorithms for Motion Estimation", The Seventh Advanced International Conference on Telecommunications, 2011.

[5] Sriram B, Eswar Reddy M, and Subha Varier G, "Study Of Various Motion Estimation Algorithms for Video Compression/Coding Standards & Implementation of an Optimal Algorithm in LabVIEW", International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 4, pp. 372-381, April 2013.

[6] Ruchi Jain, and Trupti Baraskar, "The Comparative Analysis of Various Approaches Used In Motion Estimation", International Journal of Advance Foundation and Research in Computer (IJAFRC), Volume 1, Issue 12, pp. 1-9, December 2014.

[7] Aroh Barjatya, "Block Matching Algorithms for Motion Estimation", DIP 6620 Final Project Paper, Spring 2004.

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[8] Avijit Kundu, "Modified Block Matching Algorithm for Fast Block Motion Estimation", IEEE- International Conference on Signal and Image Processing, pp. 260-264, 2010.
[9] Modukuri Sushmitha, Maher E. Rizkalla, Paul Salama, and Mohamed El-Sharkawy, "High Speed Search Algorithms for Block Based Motion Estimation Video Compression", IEEE, pp. 308-312, 2006.
[10] Rajeshwar Dass, Lalit Singh, and Sandeep Kaushik, "Video Compression Technique", International Journal of Scientific & Technology Research Volume 1, Issue 10, pp. 114-119, November 2012.
[11] S. Ponlatha, and R. S. Sabeenian, "Comparison of Video Compression Standards", International Journal of Computer and Electrical Engineering, Vol. 5, No. 6,pp. 549-554, December 2013.
[12] MuzhirShaban Al-Ani, andTalal Ali Hammouri, "Video Compression Algorithm Based on Frame Difference Approaches", International Journal on Soft Computing (IJSC) Vol.2, No.4, pp. 67-79, November 2011.
[13] Ajay, and Mahesh Prasad Parsai, "Video Compression Techniques: A Review", International Journal of Engineering Trends and Technology (IJETT), Volume 13, Number 7, pp. 318-321, July 2014.
[14] P.C.Shenolikar, and S.P.Narote, "Different Approaches for Motion Estimation", International Conference On "Control, Automation, Communication And Energy Conservation, June 2009.
[15] Darun Kesrarat, and Vorapoj Patanavijit, "Investigation of Performance Trade off in Motion Estimation Algorithms on Sub-Pixel Displacement", IEEE, 2010.
[16] S Sangeeta Mishra, Chittaranjan Pradhan, and Alka Singh, "Comparative Study of Motion Estimation Techniques in Video", International Journal of Computer Science and Information Technologies, Vol. 5, No.3, pp. 2982-2989, 2014.
[17] S. Immanuel Alex Pandian, Dr.G. Josemin Bala, and Becky Alma George, "A Study on Block Matching Algorithms for Motion Estimation", International Journal on Computer Science and Engineering (IJCSE), Vol. 3 No. 1, pp. 34-44, Jan 2011.
[18] Shaifali Madan Arora, and Navin Rajpal, "Comparative Analysis of Motion Estimation Algorithms on Slow, Medium and Fast Video Sequences", International Conference on Reliability, Optimization and Information Technology -ICROIT, India, Feb 6-8 2014.
[19] Hussain Ahmed Choudhury, and Monjul Saikia, "Comparative Study of Block Matching Algorithms for Motion Estimation", International Journal of Advanced Computational Engineering and Networking, Volume-1, Issue-10, pp. 73-78, Dec-2013.
[20] Maria Santamaria, and Maria Trujillo, "A Comparison of Block-Matching Motion Estimation Algorithms", IEEE, 2012.
[21] Jigar Ratnottar, Rutika Joshi, and Manish Shrivastav, "Review Towards Fast Block Matching Algorithm for Video Motion Estimation", IEEE-International Conference on Communication Systems and Network Technologies, 2012.
[22] S.R. Subramanya, Hiral Patel, and Ilker Ersoy, "Performance Evaluation of Block-Based Motion Estimation Algorithms and Distortion Measures", IEEE-International Conference on Information Technology: Coding and Computing, 2004.
[23] K. R. Namuduri, and Aiyuan Ji, "Computation and Performance Trade-offs in Motion Estimation Algorithms", IEEE, pp-263-276, 2001.
[24] Fenta Adnew Mogus , Xinying Liu, and Lei Wang, "Evaluation of the Performance of Motion Estimation Algorithms in Video Coding", IEEE, 2010.
[25] Angela D' Angelo, Marco Carli, and Mauro Bami, "Quality evaluation of motion estimation algorithms based on structural distortions", IEEE, 2010.
[26] Shan Zhu, and Kai-Kuang Ma, "A New Diamond Search Algorithm for Fast Block-Matching Motion Estimation", IEEE Transactions on Image Processing, Vol. 9, No. 2, pp. 287-290, February 2000.
[27] Xuan-Quang Banh, and Yap-Peng Tan, "Efficient Video Motion Estimation Using Dual-Cross Search Algorithms", IEEE, 2005.
[28] Yasser Ismail, Jason McNeelly, Mohsen Shaaban, and Magdy A. Bayoumi, "Enhanced Efficient Diamond Search Algorithm for Fast Block Motion Estimation", IEEE, pp. 3198-3201, 2009.
[29] Xuan-Quang Banh, and Yap-Peng Tan, "Adaptive Dual-Cross Search Algorithm for Block-Matching Motion Estimation", IEEE Transactions on Consumer Electronics, Vol. 50, No. 2, pp. 766-775, MAY 2004.
[30] Atalla I.Hashad, Rowayda A. Sadek, and Sara K. Mandour, "A Novel Reduced Diamond Search (RDS) Algorithm with Early Termination for Fast Motion Estimation", International Journal of Video& Image Processing and Network Security IJVIPNS-IJENS, Vol. 10, No. 04, pp. 14-22, August 2010.
[31] Ms. Bhavina Patel, Dr.R.V.Kshirsagar, and Vilas Nitnaware, "Review and Comparative Study of Motion Estimation Techniques to Reduce Complexity in Video Compression", International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, Issue 8, pp. 3574-3584, August 2013.
[32] M. Jakubowski, and G. Pastuszak, "Block−Based Motion Estimation Algorithms – A Survey", Springer-Opto−Electronics Review , Vol. 21, No. 1, pp. 86–102, 2013.

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