Multi Pattern Search Algorithm (MPSA) for Motion Estimation

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ABSTRACT

Estimation of moving objects in image sequence is a central matter in video code, as well as for a variety of tasks in image analysis, motion estimation is exploit the sequential correlation existing in video sequences. Block matching algorithm (BMA) is a technique used for estimating motion vectors in image sequence. It is manipulation divide each frame into block (rectangular or square) then according to spatial search strategy compare between block in reference farm and current frame. Proposed a new motion estimation algorithm multi-pattern search algorithm (MPSA) by considering companied matching criteria and exploit the relationship between the motion models and frames difference of each block, according to motion model choosing suitable pattern, search pattern changing the search area shape to improve motion estimation, while reducing computational complexity. The proposed algorithm is compared with common, simple implemented one which is a full search (FS) algorithm it requires very heavy computational complexity, three step algorithm (TSS), TSS traps into local minimum also these method sacrifice accurate motion estimation to reduce computation. The results show that the proposed algorithm is better according to the computational complexity and accuracy. MPSA check less number of pixel less than FS in (70%) and (30.18%) than TSS and less run time than FS in (65.62%) and (50%) than TSS.

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1-Introduction

Motion estimation has been widely used in various video coding and compression for transmission and storage of video signals [1]. Motion estimation (ME) is how to represent the changes between two successive video frames where the change occurs due to motion of object or moving camera [2]. Motion estimation techniques are based on feature correlation matching. Whenever points of motion are not presented directly, they are presented through intensity changes in 2-D motion with time-varying. The search technique presented belongs to the class of spatial-temporal approaches which exploit the information contained along image sequences and estimates directly the motion vector characteristics, regardless of the moving objects [3]. Motion estimation compares the current frame to a previous frame in order to get the difference among them, thus taking advantage of the spatial and temporal correlation between them. In order to develop a motion estimation algorithm, three important elements need to be considered: motion models used to find motion Vector, matching criteria and search strategies. This paper organized as follow: section two is for block matching algorithm which contain BMA technical and define prosperities of Full Search Algorithm (FSA), Step Search Algorithm (TSS), Cross Search Algorithm (CSA), Two Dimensional Logarithmic Search (TDL).section three is for proposed algorithm (MPSA) which explains characteristic of proposed algorithm, section four for experiments result for MPSA compare with FS, TSS algorithm, section five for conclusion.

2- Block matching algorithm (BMA)

Block matching algorithms are most common technique, because they balance between complexity and efficiency .In this method the block matching algorithms tries to obtain the motion vector, which is the actual displacement of a block with respect to the previous frame [4]. These methods are good in efficiency and computational complexity compared to the pixel methods. They are also simpler for hardware and software implementation, the resulting motion information is then exploited in displacement and velocity moving object [5]. The search pattern's shape and

size exploited in the algorithm jointly determine not only its search speed but also resulting performance. Block distortions (or block-matching errors) form an error surface over the search window, and the global minimum point corresponds to the motion vector where the best matching (the least error or great similarity) [6].In BMA, each frame is divided into rectangular or square blocks. For each block pixel in the current frame, compare with pixels in block of the previous frame that is the closest to the current block based on a certain criterion, and the relative positions of the two blocks define a motion vector associated with the current block [7] .Various BMA have been proposed for fast motion estimation. However, they are sacrificing the accuracy of motion vector (MV) in order to reduce the computational requirement [8]. Full Search Algorithm (FSA) one of the popular, simple algorithm for motion estimation used block matching algorithm (BMA) technique is full search algorithm (FSA). Full search (FS) matching algorithm consists of calculating a correlation, or distortion, at each position of a search area within reference image and current image to measure the degree of similarity, or dissimilarity, between them this determines a maximum-correlation, or minimum-distortion, position that locates in the examined image [9]. FSA has been applied widely for block motion estimation processing because it produce accurate motion vector since the FS exhaustively searches for the motion vector, minimizing search point, it generally provides good performance. However, it is very computationally expensive to find a best motion vector from the whole search range [10]. In order to reduce the computational trouble associated with (FS) several fast algorithms have been proposed. Generally take heuristic approaches to reduce the computational complexity such as Three Step Search Algorithm (TSS).This algorithm was introduced by Koga et al in 1981. It has become very popular because of its simplicity and also near optimal performance. A particular path for the convergence of this algorithm is shown in Figure (1).

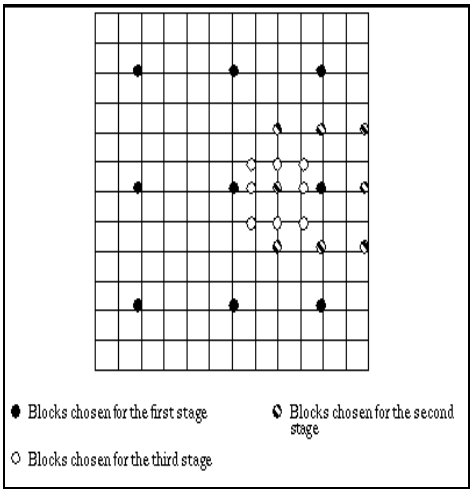


Figure (1) Three Step Search path

The algorithm in initial step size is picked. Eight blocks at a distance of step size from the centre (around the centre block) are picked for comparison. The step size is halved. The centre is moved to the point with the minimum distortion. A particular path for the convergence of this algorithm is shown in figure (1). One problem that occurs with the three Step Search is that it uses a uniformly allocated checking point pattern in the first step, which becomes inefficient for small motion estimation, and TSS achieves a small improvement than FS because it needs a big computational complexity, since it uses a uniformly allocated checking point pattern in the first step, which becomes inefficient for small motion estimation and trapped into local minimum [11].Cross Search Algorithm (CSA) this algorithm introduced by M. Ghanbari in 1990.this method presented search for candidate locations for the end points of a "x" rather than a "+". Pick the first set of points in the shape of a "x" around the centre. Move the centre to the point of minimum distortion.If the step size is bigger than 1 halve it and repeat this step but if the step size is smaller the point of minimum distortion is the bottom left or the top right point, then evaluate distortion at 4 more points around it with a search area of a "+".however, the point of minimum distortion is the top left or bottom right point, evaluate the distortion at 4 more points around it in the shape of a "x" .Cross

search algorithm requires 5 + 4 log2N comparisons, where N is the block size . [1].

Two Dimensional Logarithmic Search (TDL),this algorithm was introduced by Jain is closely related to Three Step Search. The algorithm may be described as follow :

initial step size look at the block at the center of frame and the four blocks at a distance of this center block on the X and Y axes. (the five positions form a + sign).If the position of best match is at the centre, halve the step size. If however, one of the other four points is the best match, then it becomes the centre and repeated this step.this algorithm requires more steps than the Three Step Search which mean more computaion followed with long time, accurate this algorithm depnd on block size,get better result especially when the search window is large [7].

3-The proposed motion estimation algorithm

The proposed algorithm Multi Pattern Search Algorithm (MPSA) reduces the computational complexity without sacrificing accuracy. The correct detect motion vector by modified search area depending on motion model. (MPSA) consider statistical properties between the object displacement and the frame difference of each block, change the search pattern shape depending on motion model and it does not increase the number of search points in next step but which was checked in the pervious step. The proposed algorithm can reduce the computational complexity compared with other BMA and producing good motion estimation. In order to reduce the complexity of the block matching operation, Most of the blocks can be regarded as stationary or quasi-stationary such as image background so can define another matching criterion by combining main absolute different (MAD) and main pel count (MPC) the idea of the new matching criterion is that we count only the pixel differences that have significant changes of luminance values the motion factor not included in the computational because small change may occur for another reason such as noise. Since the pixels that have small changes of luminance values are not included in the computations, the complexity is reduced substantially without sacrificing accuracy;

one difficulty with the new matching criterion is the selection of the threshold value (THS).

$$\mathbf{T(k,j,l,i)} = \begin{cases} 1 \text{ if } \left|I_t(K,l) - I_{t-1}(K+i,l+j)\right| \le ths \\ 0 \quad \text{other wise} \end{cases} \quad \text{-----1}$$

$$\mathbf{SAD} = \sum_{K=1}^{N}\sum_{L=1}^{N} T(k,l,i,j)\left|I_t(k,l) - I_{t-1}(k+i,l+j)\right| \quad \text{-----2}$$

Let $I_t(K,I)$ be the luminance pixel values of the current frame, and $I_{t-1}(K+i,I+j)$ be the luminance of the previous frame. (i,j) represents the displacement vector, NxN size of a square block

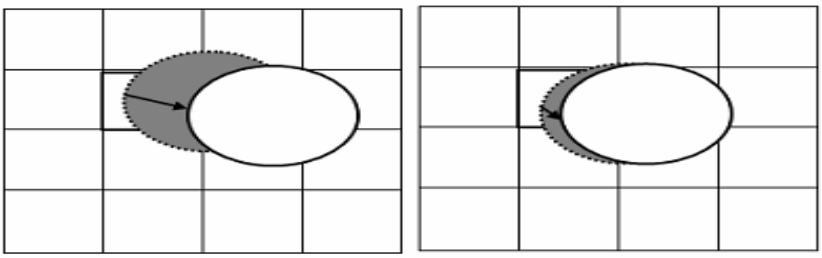


Figure (2) Relationship between Motion and BFD in Block

The motion vectors for those blocks are enclosed in the central area. Considering two cases, as shown in Figure (2), a large movement will make a large block frame difference (BFD) within the search range a small movement will make a small block frame difference (BFD) within the search range.. However, there are some exceptional cases.

Case 1: BFD is smaller than the threshold value, but the movement is large. This case can occur when there is a noise in the stationary region. By examining BFD, assume that the block has small motion.

Case 2*:* BFD is larger than the threshold value, but the movement is small. This case may happen when there is a large difference between the background and objects. If the

number of representative pixels is small, we can assume that this case occurred and the block has small motion. If movement for the block is small, the search range is limited to a square region as shown in Figure(3) and If movement for the block is large the search area is diamond region as shown in Figure(4). Important points of considerations when implement algorithm:-

1) **It should not be trapped at any local minimum.**
2) **In order to follow the correct direction, assignment of initial search points should be detecting motion model local (Global motion occurred when object and camera both of them are moving while local mot ion occurred when object only is moving).**
3) **Additional search points in the second step should be small and must be reduced and omitted points in the previous step is checked the search area is more compact, but it does not increase the number of search points than the others in the second step. The number of search positions in the second step is different and determined according to the location of previous point.**

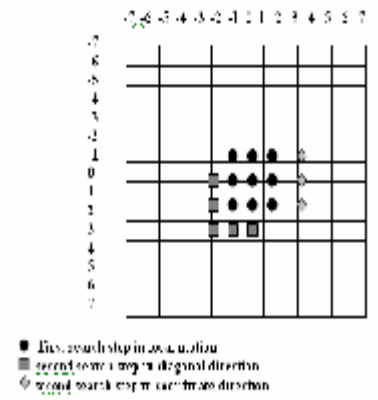


Figure (3) local motion pattern

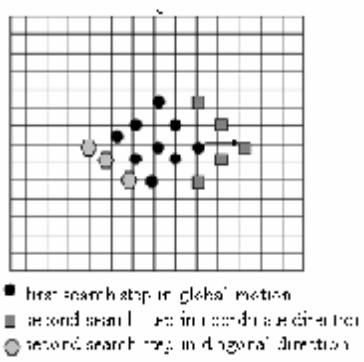


Figure (4) global motion pattern

Small changes of luminance values, assuming that this case occurred and the block has small motion, in the proposed algorithm consider square initial search pattern shape and large

motion diamond initial search pattern shape for best possible in the computational complexity. The proposed algorithm (MPSA) is summarized as follows:

Step 1: A minimum point is searched from 9-search points on search region centered at (0, 0). In the points which locate in the vertical, horizontal or diagonal, square search pattern is spaced by 1 point from the origin of search region direction, while the other which locate in the diagonal direction is spaced by 2 point from the origin of search region. Compare block points in reference frame with block points in current frame if BDF is larger than THS value then the minimum point is found at the center of the search region detect motion in search area then it goes to step 3.

Step 2: In this step, there is two kind of search pattern in terms of previous minimum position. This step can be performed iteratively until it reaches the minimum point in the origin of search region.

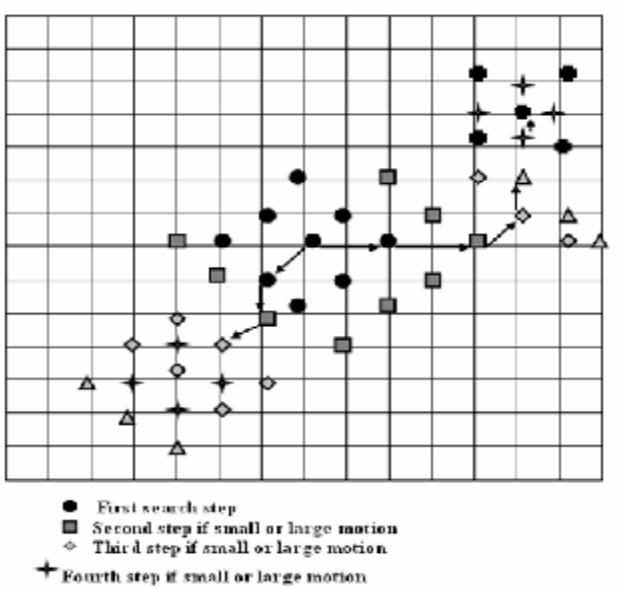


Figure (5) Search Pattern of MPSA

If motion model is global the search direction as follow:

a) If the previous minimum point is in the diagonal of previous search region, three additional search points are used along that point.

b) If the previous minimum-point is in the vertical or horizontal of previous search region, five additional search points are used along that point. This procedure can be depicted as Figure (4).

If motion model is local the search direction as follow:

a) If the previous minimum point is in the diagonal of previous search region, five additional search points are used along that point.

b) If the previous minimum-point is in the vertical or horizontal of previous search region, three additional search points are used along that point. This procedure can be depicted as Figure (3).

Step 3: Search the minimum point among the nine points around the previous minimum point, one by one figure (5).

4- Test MPSA Results

The experimental result test of algorithm which is described in section three, this algorithm is implemented by simple H.W (1.8 CPU, 512 RAM). different video file format with different length for five clip acquired by single camera split into 30 F\S frame resolution (352*288), original image used as reference frame to generate image with estimation motion, each frame employ 396 blocks, block with size (16*16) each one have 256 pixel. Five video are tack in one camera, camera property (Sony D cam. with 990 xx power resolution, wide angle).Video used for test result which are:

Video1 (girl) include one slowly moving object parallel with camera movement direction and global motion dominate in video with length (time) 2:33:56 sec.

Video2(child) include one moving object but camera move fast compare with child move (face expression) local motion govern in video, video length (time) 4:17:34 sec.

Video3(ball) include one object static and camera move quickly perpendicularly on object so any change occur in image intensity result from camera movement, video length (time) 0:57:24 sec.

Video4 (boy) include one slowly moving object, object move local motion in video (face expression) with length 2:37:47sec.

Video5 (twin) include two moving object. Global motion dominate for object1 (girl) while object2 (ball) local move dominate, with length 2:33:56 sec.

Depending on search procedure checked number of pixel which is examined in each step for MPSA compare with FSA and TSSA. From search procedure notice that FS exams all pixel in each block while TSS used regular pattern repeat in each step but MPSA change number of examining pixel according to dominate type of motion wither global or local also omitted point examined in previous step for this reason MPSA less computational with less run time, obtained results are shown in table (4-1).

Table 4.1average no. pixel check

Estimation method	Searching point	block size
FS	**256 pixel**	**16 * 16**
TSS	**25 pixel**	**16 * 16**
MPSA	**14 pixel**	**16 * 16**

Image quality was measured by the mean square error (MPE) which equal

$$\text{MSE} = \frac{1}{MN} \sum_{M}^{M-1} \sum_{N}^{N-1} (F_r(m,n) - F_e(m,n))^2$$

$$\text{MSE} = \frac{1}{MN} \sum_{M}^{M-1} \sum_{N}^{N-1} (F_r(m,n) - F_c(m,n))^2$$

Where F_r reference frame, F_e estimation frame, F_c current frame M, N width and height of frame respectably. Using MSE to compare between current and estimation frame on FS, TSS, and MPS algorithms. reference frame current frame ,estimation frame, motion vector show in Figure (6), results obtain show in table (4-2) from table (4-2) found MSE is more accurate to detect motion vector than FSA,TSS as show in figure(7) also clear to notice that MPSA performance patter when detect a small motion in image which mean MPSA more accurate estimation for video with local motion. The RGB color model is the most common generally used, it is implemented in different ways, depending on the capabilities of the system used but YIQ color model is better to use in video color .find that estimation become more accurate for same video when execute MPSA algorithm using YIQ than using RGB color is better special for video contain more than one moving object and reduce time processing in (5%) as show in figure(8)

Table 4.2: performance algorithms using MSE

Video	Frame size	FS	TSS	MPSA
Video1	352*288	0.0	5.56	0.88
Video2	352*288	22.69	15.97	8.7
Video3	352*288	28.71	11.932	7.2
Video4	352*288	0.0	49.59	26.3
Video5	352*288	25.01	2.15	10.72

Figure (6)
Video-1

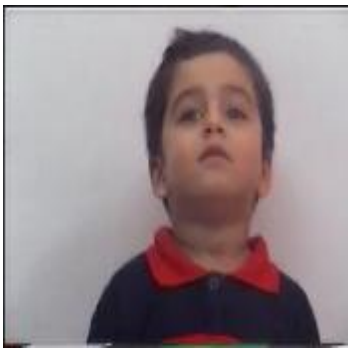
Reference frame

Current frame

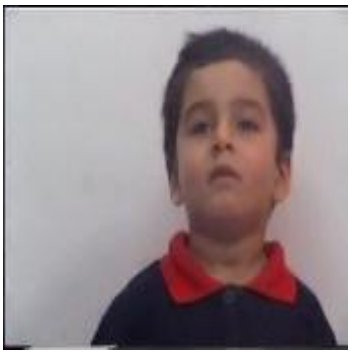
Estimation frame

motion vector

Video -2



Reference frame



Current frame

Estimation frame

motion vector

Video-3

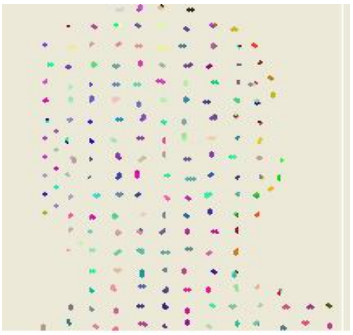
Reference frame

Current frame

Estimation frame **motion vector**

Video-4

Reference frame **Current frame**



Estimation frame **motion vector**

Video-5

Reference frame

Current frame

Estimation frame

motion vector

Figure -7

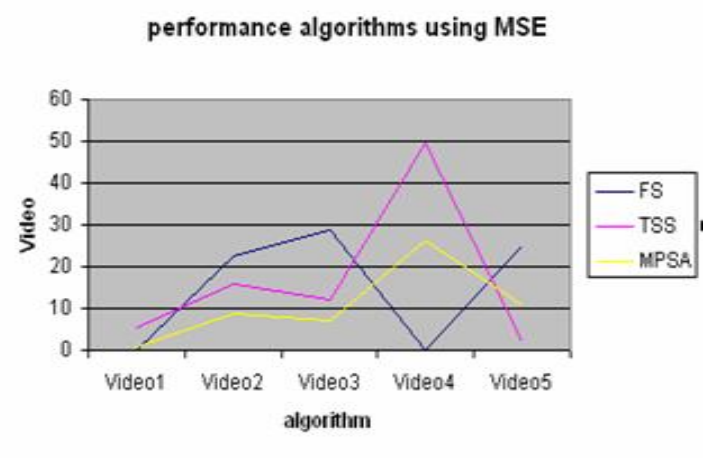
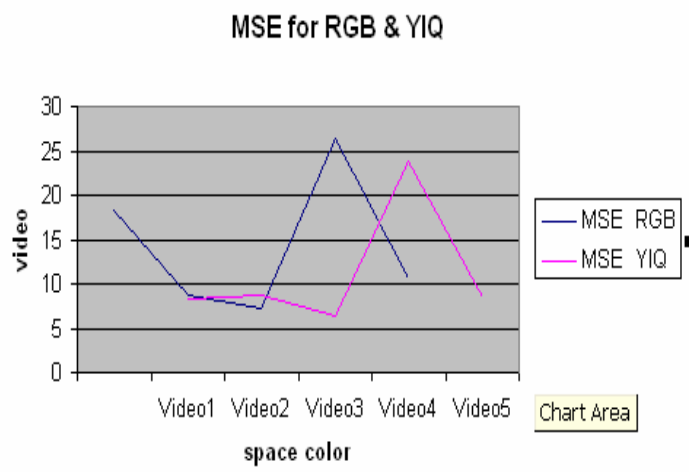


Figure -8



4. Conclusion and future work

In this paper, we have proposed multi-patron search algorithm MPSA block matching algorithm with a new matching strategy that employs different search patterns by observing t movement type in each block. Considered a new matching criteria for block matching to provide, new algorithm can reduce the 'computational complexity compared with previously BMA such as FS,TSS , while maintaining estimation accuracy close to FS.

MPSA check less number of pixel less than FS in (70%) and (30.18%) than TSS and less run time than FS in (65.62%) and (50%) than TSS. The future work can calculate optical flow (MV) from using a presence of single blur image because the blur give direction of motion so there is no need for more than one image .Almost ME algorithm work on spatial domain, in the future work try to estimates motion in frequency domain.

5. Refrence

[1] M. Ghanbari, "The cross-search algorithm for motion estimation," IEEE Trans. Commun., vol. COM-38, pp.vol. 3, no. 1, Feb. 1993.

[2] cliff wootton" a practical guide to video and audio compression" , 2003, Technology Department in Oxford, UK.

[3] David Salomon, Data Compression (Third Edition), Department of Computer Science California State University, Northridge, Northridge, CA 91330-8281, USA.

[4] Ling-Yu Duan, Jinqiao Wang, Yantao Zheng, Changsheng Xu, Qi ,"Shot-Level Camera Motion Estimation Based on a Parametric Model ",2001, IEEE Trans. Image Processing.

[5] Keith Jackvideo," demustified a hand book for the digitel engineer third eddition",2001,LLH Technology Publishing, Eagle Rock.

[6] Kuo-Liang Chung, "A New Predictive Search Area Approach for Fast Block Motion Estimation",2003, IEEE Trans. Image Processing.

[7] L.M. Po and W.C. Ma, "A novel four-step search

algorithm for fast block motion etsimation," IEEE.Trans. Circuit and Systems for Video Technology, vol.6, no. 3, pp. 313-317, June 1996.

[8] L.W. Lee, et al., "Dynamic search-window adjustment and interlaced search for block-matching algorithm," IEEE Trans. Circuit and Systems for Video Technology,

[9] Wei-Gang Chen ,"Noise Variance Adaptive SEA for Motion Estimation: A Two-Stage Schema",2005, School of Computer and Information Engineering, Zhejiang Gongshang University.

[10] M.J. Chen, et al., "A new block-matching criterion for motion estimation and its implementation," IEEE Trans.Circuit and Systems for Video Technology, vol. 5, no. 3, pp. 231-236, June 1995

[11]Berd jahne,"digital image processing 5th revised and extended edition",2001, springer.

خوارزمية البحث متعددة الانماط لتخمين الحركة

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المستخلص

تخمين حركة الجسم في صور متسلسلة مشكلة مركزية في لتشفير ألفديو بالاضافة الى مجموعة وظائف مختلفة لتحليل الصورة, تخمين الحركة يتضمن استغلال العلاقة المؤقتة الموجودة في الفديو المتسلسل, خوارزمية تطابق البلوك (BMA) تقنية تستخدم لتخمين متجه الحركة في الصورة المتسلسلة. تعمل على تقسم الصورة الى مربع او مستطيل متساوي الحجم ثم وفقا الى تقنية بحث خاصة مقارنة البلوك في الصورة السابقة والحالية. الخوارزمية المقترحة الجديدة لتخمين الحركة هي خوارزمية البحث المتعدد الباترونات (MPSA) باستخدام عامل مطابقة مركب و استخلاص العلاقة بين موديل الحركة ومقدارالاختلاف في بلوك الصورة, وطبقا الى موديل نختار نمط البحث المناسب, انماط البحث يتغير شكل مساحة البحث لتحسين تخمين الحركة لتقليل تعقيد الحسابات. الخوارزمية المقترحة نقارنها مع الخوارزمية الاكثر شيوعا والسهلة البناء (FS) لتخمين متجه الحركة والتي تتطلب حسابات معقدة وكثيرة, خوارزمية البحث بثلاث خطوات (TSS), خوارزمية (TSS) تعاني من مشكلة النقطة المحلية. هذه الطرق تضحي بالدقة في تخمين الحركة لاجل تقليل تعقيد الحسابات. نتائج الخوارزمية المقترحة تبين انها الافضل من ناحية تقليل الحسابات اي سرعة المعالجة والدقة. (MPSA) تفحص عدد نقاط اقل من(FS) بمقدار(70%) و(30.18%) من(TSS) وزمن تنفيذ اقل من(FS)) بمقدار(65.62%) و(50%) اقل من (TSS)

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هناك عدة طرق لتقليص شبكات Petri التي تلعب دوراً مهماً في تطبيقات واسعة المجال. في هذا البحث سيتم تقديم نموذج جديد ومختلف لتقليص شبكات Petri. النموذج المقترح يعتمد على تحويل شبكات Petri الى برنامج منطقي ومن ثم معالجة هذا البرنامج من خلال تقنية القواعد الارتباطية باستخدام خوارزمية Apriori لاستخراج العلاقات المنطقية لقواعد الانتاج والتي تؤدي الى تقليص البرنامج المنطقي. وفي النهاية يتم اعادة بناء شبكات Petri من خلال البرنامج المنطقي المقلص. اثبتت التجارب التي اجريت على ان الطريقة المقترحة جيدة وكفوءة ومنطقية في عملها لتقليص شبكات Petri.