New Selective Block Matching Searching Algorithm Based on Block Discriminator Values For Motion Estimation

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ABSTRACT:

In this paper, a new, fast and efficient selective block matching algorithm based on block discriminator values is suggested. The searching scheme consists of three stages: block discriminator values calculations, open full window then cascaded selection sub stages have been applied where each sub stage uses distinct block discriminator value to select sub set of candidate search points and finally perform block distortion measurement calculation to the latest candidate search points to find the best match. The famous Exhaustive Search (ES) and Three-Step Search (TSS) algorithms are used to compare with proposed algorithm. The experimental test shows that the proposed searching method results in compare with TSS algorithm, produce results little slower in term of search time but better in term of distortion measurement when the size of search area is [-6,6]. Results in compare with ES show that the proposed searching method produces results near the ES in term of distortion measurement but faster than it in term of search time when the size of search area is [-7,7].

Keywords: Motion Estimation, Block Matching Algorithm, Block Distortion Measurement, Exhaustive Search , Three Step Search.

خوارزمية بحث انتقائية جديدة لمطابقة الكتل مستندة على قيِم مميّزُ الكتل لتقديرِ الحركةِ

الخلاصة

في هذا البحث, تم اقتراح خوارزمية سريعة وكفوؤة لمطابقة الكتل مستندة على قيم مميز الكتل. مخطط البحث يَشْملُ ثلاث مراحلِ: حسابات ُقيِّمُ مميّزُ الكتل, فتح نافذة كاملة للبحث متبوعة بمراحل فرعية متعاقبة الاختيار ِمطبقة بحيث انه كل مرحلة فرعية تستخدم مميز كتلة مختلف لاختيار مجموعة جزئية من نقاط البحث المرشحة , أخيرا انجاز حساب مقياس التشويه للكتل على نقاط البحث المرشحة لإيجاد أفضل مطابقة. استخدمت خوارزمية البحث الشامل المشهورة وخوارزمية خطوات البحث الثلاثة للمُقَارَنَة بالخوارزميةِ المُقتَرَحةِ. اظهر الاختبار التجريبيَ بأنّ طريقةَ البحث المُقتَرَحةِ بالمقارنةِ بخوارزميةِ خطوات البحث الثلاثة, أبرزت ناتج أبطأ قليلا من حيث وقت البحث لكنه أفضل من حيث مقياسِ التشويهِ عندما يكون حجمِ منطقةِ البحثِ [-6,6]. النتائج بالمقارنة مع خوارزمية البحث الشامل بينت أن طريقةَ التَفتيش المُقتَرَحةِ أبرزت ناتج مقارب من حيث مقياسِ التشويهِ لكن أسرعَ من حيثِ وقتِ البحثِ وعندما يكون حجمِ منطقةِ البحثِ [-7,7].

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INTRODUCTION

The great advances in real-time and portable multimedia contrivances necessitate the desideratum for a computationally efficient video codec design that will permit for a reliable and robust video quality.

Inter-frame processing is the key to exploit and reduce the temporal redundancy in digital video compression, where Motion Estimation ME are the basic approaches to ascertain and represent the motion between frames (i.e. utilize the homogeneous attribute between consequent frames). These technique are widely used in video standards (including H.26x and MPEG) to achieve high data compression rate [1].

Block Matching Motion Estimation BMME is the core of video coding systems; it is the most significant component for any motion compensated video coding standards [2]. Because of its simplicity and facilitate of implementation the BMME methods became the most popular methods for motion estimation [3]. It divides frames into equal sized non-overlapping blocks and calculates the displacement of the best matched block from the previous frame as the motion vector of the block in the current frame within the search window. Block-Matching process consumes a significant segment of time in the encoding step [4].

To improve BBME search time, there are two search approaches: first examined all points in the search window like the famous Exhaustive Search ES[5] that determine the optimal motion vector for by testing all blocks in the search region, successive elimination algorithm[6] , Multi-level Successive Elimination Algorithm (MSEA)[7] , which are similar to ES method but eliminates certain search points based on the Minkowiski's inequality.

The second approach formally adopted to reduce computational complexity by using relatively few points without degrading image quality like: The Three Step Search TSS [8], The New Three Step Search NTSS[9], Four Step Search FSS [10], the Diamond Search DS[11],Hexagone-based Search (HEX)[12] and Unsymmetrical-cross-multi-hexagon grid search UMHexagons [13] .

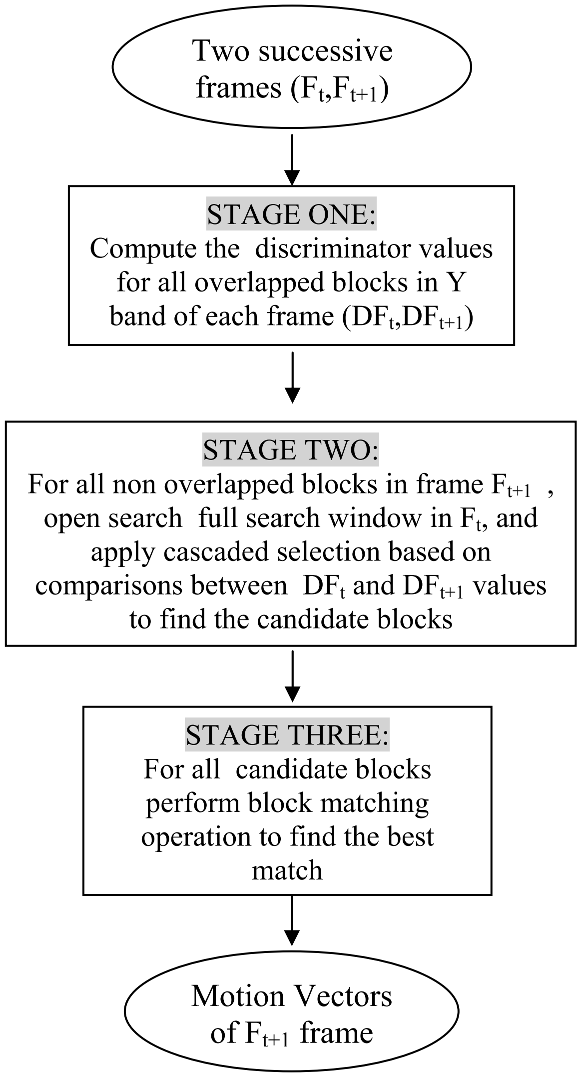
In this paper, a block matching search algorithm is proposed that start the search by full search window, but does not match all blocks within the window with the target block like ES. The algorithm worked by select candidate block from the search window to be matched later using any block distortion measurement to find the best match. The selection based on single values assigned to each overlapped blocks within the search area, these values discriminate one block from the other called block discriminators which are functions of block content.

Heavy investigation has been done to find suitable block discriminators that serve the proposed search scheme that called Discriminator Based Search Algorithm DBSA.

The rest of this paper is organized as follows: Section 2 contains the proposed search system layout. The established proposed system is tested using some commonly used digital videos, and the test results listed and discussed in Section 3, finally the derived conclusions are listed in section 4.

The Structure of Roposed Search System

Anyone who has watched movies knows that the difference between consecutive frames is small because it is the result of moving the scene, the camera, or both between frames. ME creates a model of the current frame based on available data in one or more previously encoded frames (reference frames)[14]. The structure of the proposed search system summarized in Figure (1)



Figure(1). Proposed Search System Diagram

So the algorithm consist of three stages each will be explained in details in the following subsections:

A. STAGE ONE:

In this stage the two input frames first must converted from RGB color model to YUV color model . Secondly for each overlapped block of Y band compute the block discriminator values using the following equations:

- First block discriminator equation[15]:

$$mean_{Discr1}(x,y) = \frac{1}{L^2} \sum_{r=x}^{x+L-1} \sum_{c=y}^{y+L-1} f(r,c) \qquad \dots (1)$$

- Second block discriminator equation:

$$xc = \frac{(L-1)}{2} \quad \dots (2)$$

$$w(i) = \frac{(i-xc)}{xc} \qquad for\ i = 0,1,..L-1 \quad \dots (3)$$

$$momx_{Discr2}(x,y) = \sum_{r=x}^{x+L-1} \sum_{c=y}^{y+L-1} f(r,c) * w(r-x) \quad \dots (4)$$

- Third block discriminator equation:

$$momy_{Discr3}(x,y) = \sum_{c=y}^{y+L-1} \sum_{r=x}^{x+L-1} f(r,c) * w(c-y) \quad \dots (5)$$

Where :

L is the block length, x,y is the top left corner coordinates of each blocks (i.e. the start point of the block)

$mean_{Discr1}$ is represent the mean of the block.

$momx_{Discr2}$ and $momy_{Discr3}$ are 2nd and 3ed represent 1st order moments around x coordinate and around y coordinate respectively.

B. *STAGE TWO:*

This is the selection stage that selects sub set of candidate blocks to be passed to the next stage and the following steps explain the flow of this stage:

Step1: Specify the Size of Search Area SSA then for all blocks in the target frame to be searched in the referenced frame do the following steps.

Step2 Circular search strategy are used to compute the difference between first block discriminator value mean $_{Discr1}$ of the target block and all overlapped blocks in the search area and its accomplished using the following City Block distance equation[15]:

$$Dif_{(x,y)} = \lceil |\text{mean}_{\text{Discr1}}(\text{x},\text{y}) - \text{mean\_targ}_{\text{Discr1}}(\text{x},\text{y})| \rceil \quad \dots \quad (6)$$

all the differences satisfy **Selection Condition1** will be selected to be stored in sequential list called List_Dift1 where each entry of it contains three values (Difference, X and Y are the top left corner coordinates of the block) . Then List_Dif1 is sorted in an ascending order according to the Difference entry and if the number of items of the sorted List_Dif1 greater than β2 then half of them is passed to the next selection step.

SelectionCondition1:

$$if \left[Dif_{(x,y)} < (\text{Max\_Dif} - \sigma 1) \wedge \left(\begin{matrix} \text{the distance of the block position from the position of search} \\ \text{area center} < \beta 1 \end{matrix} \right) \right]$$

Where

(Max_Dif) is the maximum computed difference and σ1value is relative to the value of Max_Dif . It may be set to zero if Max_Dif less than or equal 10 and incremented by one repeatedly if Max_Dif greater than 10. .

Step3: for all passed blocks indexes (x,y) stored in List_Dif1 calculate the distance of their second block discriminator value $momx_{Discr2}(x,y)$ from the target block discriminator value $momx\_ targ_{\ Discr2}$ using eq. 6 . All the differences satisfy **Selection Condition2** is stored in new sequential list called List_Dif2 with the same entry definition of List_Dif1. List_Dif2 also will be sorted in ascending order according to the Distance entry. But not all the List_Dif2 entry will be passed to the next step, if their items length greater than β3 half of its content will be passed .

$$Dif_{(x,y)} = \left\| \frac{mx_{Discr2}(x,y) - mx\_targ_{\ Discr2}}{|mx_{Discr2}(x,y)| + |mx\_targ_{\ Discr2}| + \alpha} * nbin \right\| \quad \dots (7)$$

Where :

α is bias value to avoid division by zero or very small value .

nbin is number of bins to quantify the value of distance to be integer and within the range [0..nbin] , DBSA searches done when (α =10) and (nbin=30).

Selection Condition2: $if\left[\ Dif_{(x,y)} < (\text{nbin} - \ \sigma 2)\right]$

Step4: all calculations done in step3 repeated to compute distance number three using third block discriminator value myDiscr3(x,y) to produce List_Dif3 that all entry must satisfy the **Selection Condition2** and sorted. Now, Select only N number of block indexes from List_Dif3 that represent the candidate blocks that will be passed to the next stage.

C. STAGE THREE:

For all N candidates blocks calculate Sum of Absolute Difference SAD from the target block and select the minimum one, but if the computed SAD less than γ skip the remaining blocks and then computes Motion Vector MV.

Results

Many sets of tests were conducted to access the concert of the proposed searching scheme DBSA. As video test samples Foreman and Family, (with frame size specifications: size=320x240 pixels, pixel color depth=24 bit) have been used.

Several parameters were taken into consideration to study the performance of the suggested DBSA. Some of these parameter has significant effect and the other has not. The effects of the following parameters have been investigated: (1) β1, (2) β2, (3) σ3, (4) β3 and (5) N. Table (1) presents the adopted default values of these parameters, these values are selected after making a comprehensive tests and choosing the best value of parameters.

Table (1) The Control Parameters Default Values

Parameter	Range	Default
β1	[6..18]	10
β2	[80..110]	95
σ2	[5..10]	7
β3	[50..90]	60
N	[6..14]	12

Table (2)lists Comparison between the MAE and the Searching Time ST in sec. for testing applied on the test videos using different searches methods (ES with SSA [-7,7] and [-6,6], TSS and DBSA with SSA [-7,7] and [-6,6]). The result is an average of 5-runs (frame1, frame2 and frame3,frame 4 and frame5). The tests is done with block size 8x8 for all search methods.

Table (2) : Comparison between MAE and ST For testing applied on the test videos using different searches methods (ES-SSA6, ES-SSA7, TSS, DBSA-SSA6, DBSA-SSA7).

	Family		Foreman	
Methods	**MAE**	**ST(Sec.)**	**MAE**	**ST (Sec.)**
TSS	3.63144	0.02514	4.88463	0.02918
DBSA-SSA6	3.61908	0.03042	4.72834	0.03186
DBSA-SSA7	3.47322	0.03348	4.71251	0.03331
ES-SSA6	3.23744	0.08448	3.90198	0.08350
ES-SSA7	3.38926	0.10960	3.32895	0.11013

Figure (2) Shows the summarize the testing results that compare the performance of the searches method in term of MAE, but Figure (3) make the comparisons in term of ST.

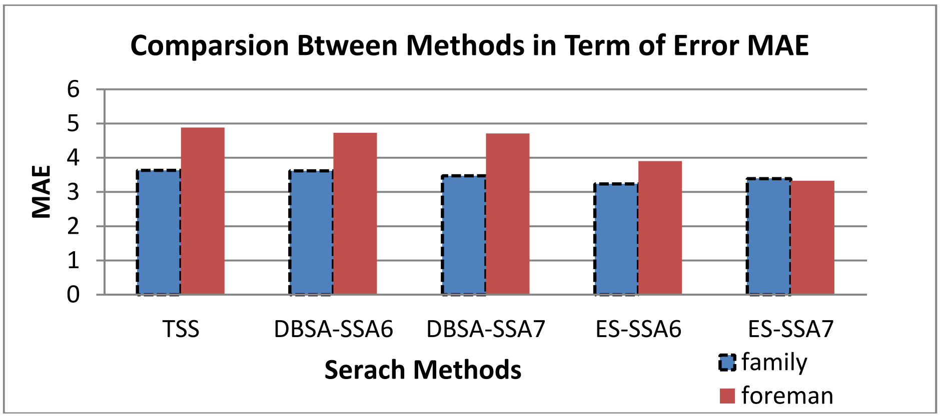


Figure (2).Testing results that compare the performance of the searches method in term of MAE

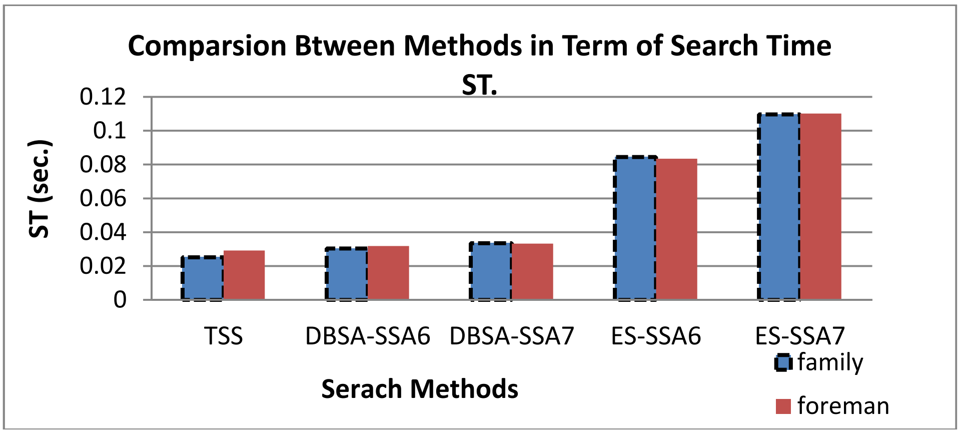


Figure (3).Testing results that compare theperformance of the searches method in term of ST.

Figure (4) select one video (family) to make the comparisons between method's performance in term of MAE vs. ST(sec.)

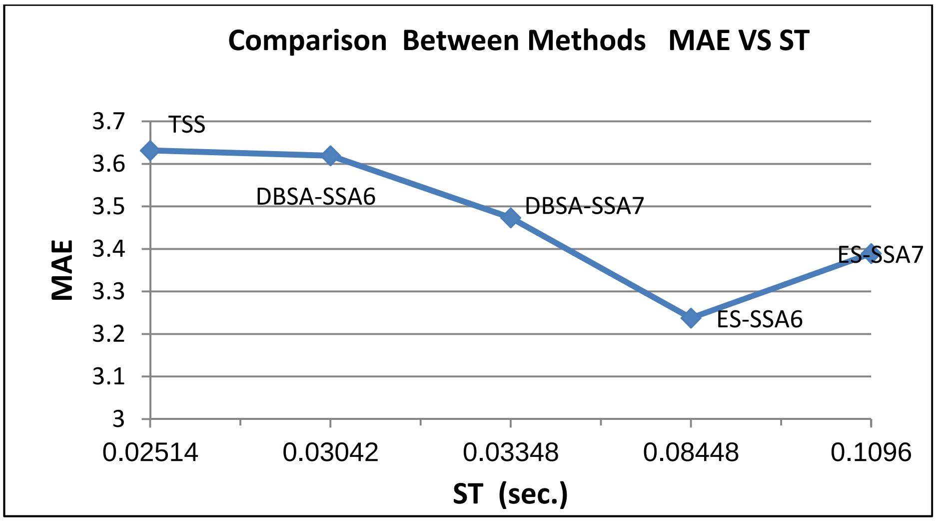
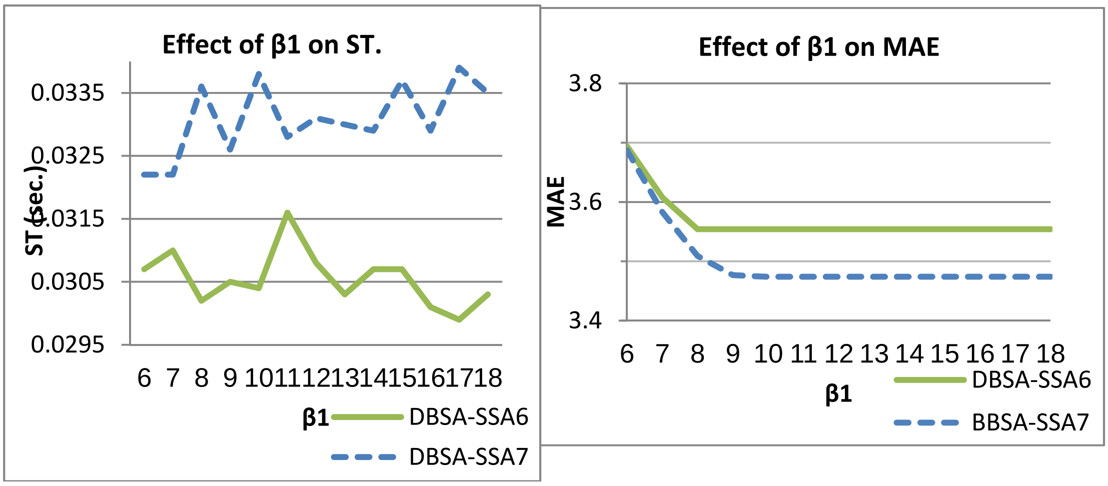


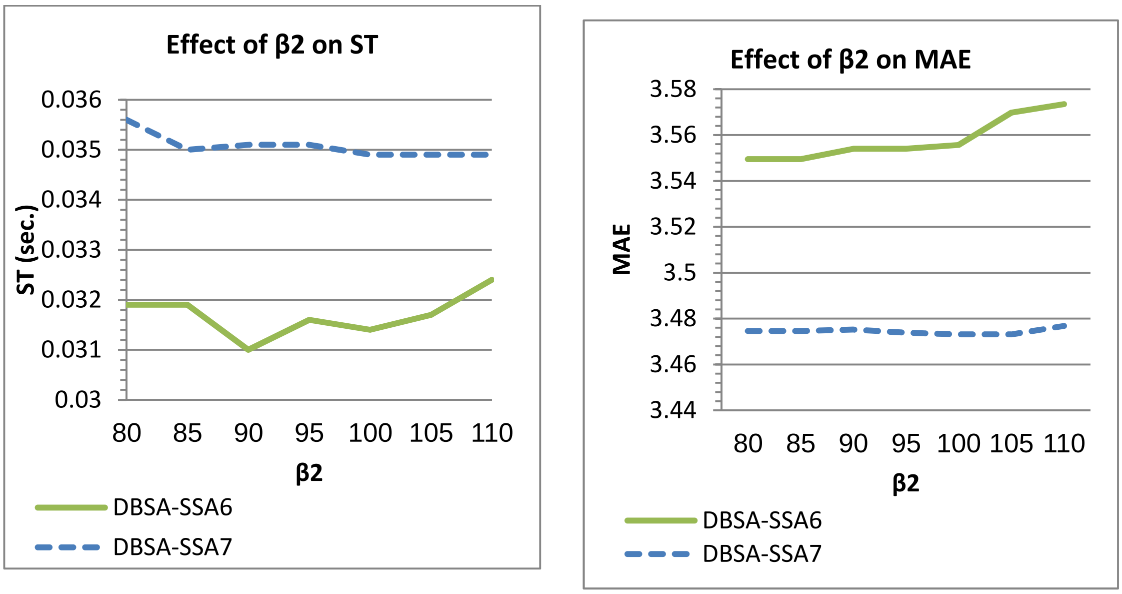
Figure (4).The test results for comparing the performance of different search methods in term of MAE vs. ST for (Family).

Figure (5.a) and Figure (5.b) presents the effects of β1 on Time and MAE respectively. While, Figure (6.a) and Figure (6.b) shows the effects of β2 on Time and MAE respectively, figure (7.a) and figure (7.b) presents the effects of σ3 parameter on Time and MAE respectively, figure (8.a) and figure (8.b) presents the effects of β3 parameter on Time and MAE respectively finally figure (9.a) and (9.a) presents the effects of N parameter on Time and MAE respectively. All these parameter effect applied on Family video. It is ostensible that these parameters cause different effects with increase parameters or decrease.



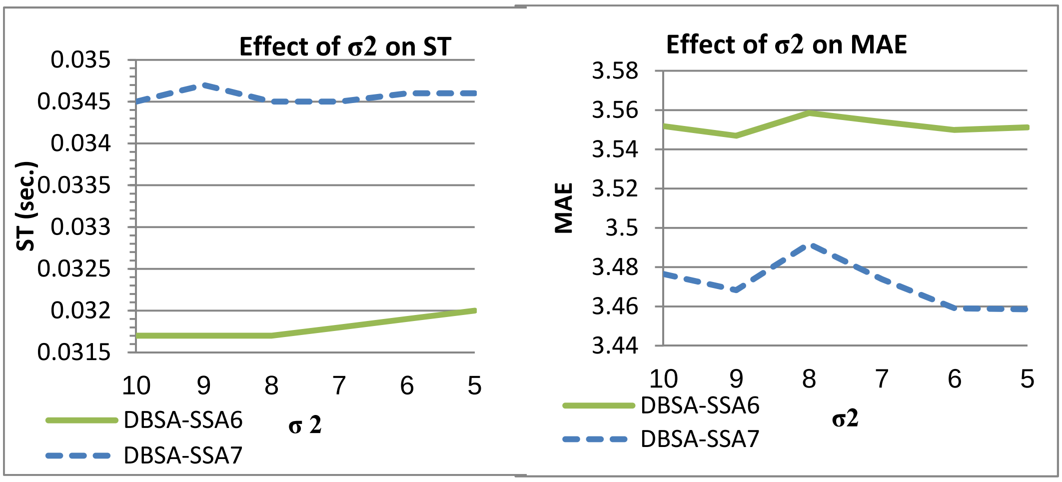
a. **b.**

Figure (5). Effect of β1 (a. On ST b. On MAE)



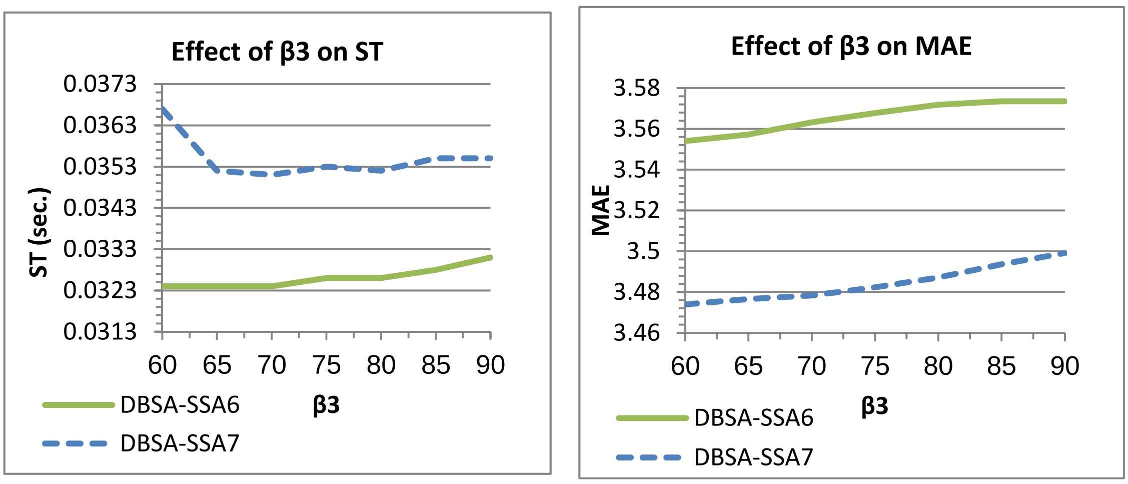
a. **b.**

Figure (6). Effect of β2 (a. On ST b. On MAE)



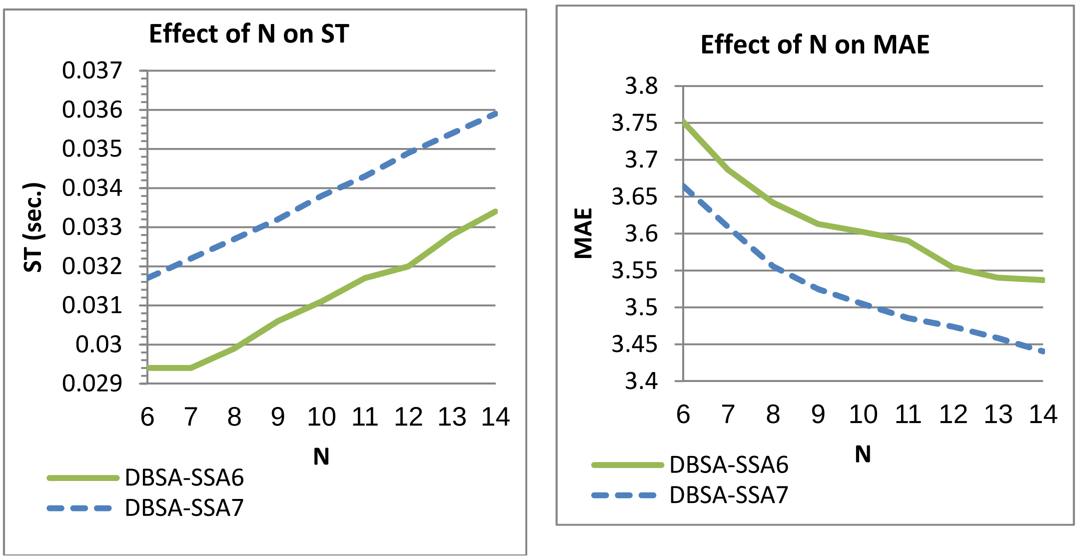
a. **b.**

Figure (7). Effect of σ2 (a. On ST b. On MAE)



a. **b.**

Figure (8). Effect of β3 (a. On ST b. On MAE)



a. **b.**

Figure(9). Effect of N (a. On ST b. On MAE)

CONCUSIONS

From the results of the proposed DBSA, the following notes are motivated:

- The proposed DBSA-SSA6 produced results little better than the standard TSS in term of distortion measurement but little slower than it in term searching time.
- The proposed DBSA-SSA7 produced results near the standard ES in term of distortion measurement but faster than it in term searching time.
- For future, the proposed DBSA can be improved by adding another block discriminator relative to mean may be standard deviation gain better results (i.e. minimum MAE near ES with ST faster or near TSS where it's our goal).
- An efficient predictive searching strategy may be added to minimize the SSA

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