# A Study of Efficient Search Location Model for Fast Search Algorithm

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**Abstract :** For motion estimation, the block matching algorithm is widely used to improve the compression ratio of low bit-rate motion video. As a newly developed fast search algorithm, the nearest-neighbors search technique has a drawback of degrading video quality while providing higher speed in search process. In this paper, a modified nearest-neighbors search algorithm is proposed in which a double rectangular shaped search-candidate area is used to improve video quality in encoding process with a small increasing of search time. To evaluate the proposed algorithm, other methods based on the nearest-neighbors search algorithm are investigated.

## I. Introduction

Recently, a number of video compression techniques have been introduced to process huge amount of data required for the transmission and the storage of motion video in multimedia applications such as MPEG-1, MPEG-2, HDTV, and H.261/H.263. These techniques reduce time correlation by motion estimation between picture frames for video compression.

Motion estimation underlines the core of motion compensated predictive coding of image sequences. For motion estimation/compensation in most video coding systems, pel recursive algorithm, frequency-domain algorithm, gradient algorithm, and block-matching algorithm are frequently used. The gradient algorithm is used in video sequence analysis and the pel recursive algorithm is used in video sequence coding. The frequency-domain algorithm is based on relationships between coefficients in transformed images but it is not widely used for video sequence coding. The block matching algorithm is based on a cost function. Cost functions are used to estimate the differences between any two given blocks.

In the block matching algorithm, the complexity of motion estimation is reduced by applying minimum value of SAD(Sum of Absolute Difference) that is absolute sum of differences between estimated motion vectors and pixel values in two given blocks. While a full search algorithm evaluates all the weighs in search area, a fast search algorithm only evaluates a subset of weights in the search area. Therefore, fast search algorithms such as logarithmic search, three-step search, and conjugate direction search are developed. In ITU TMN8(Test Models for the Near-Term, version 8) model for H.263 based video compression, nearest-neighbors search algorithm is proposed.

This paper focuses on the improvement of video quality by employing a modified nearest-neighbors algorithm since the nearest-neighbors method provides lower video quality even though it reduces search time.

## II. Search Algorithms

The full search technique is to find the best possible weight in the search area by evaluating cost functions for all possible displacements in the search range. A full search is performed for every pel and line displacement within the search window and cost functions are computed for each macro block (16×16). The size of the search window is ((M+2m2) × (N+2n1)) and the range of motion vectors is ±n1 pels and ±m2 lines as shown in Figure 1.

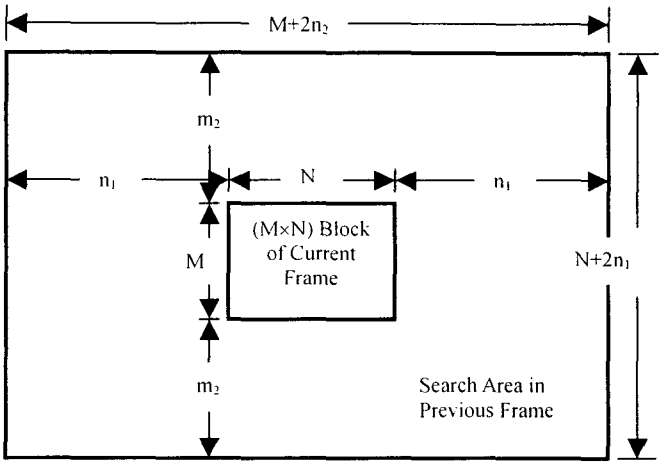
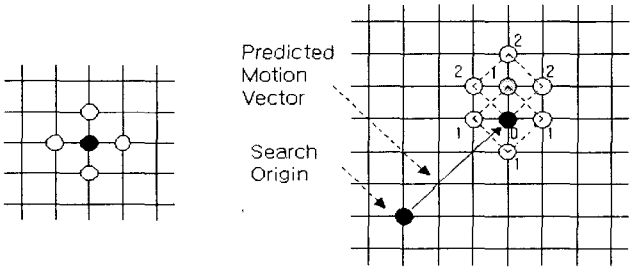



Fig 1. Full Search Algorithm

Because of heavy computing time of full search, a fast search algorithm for low bit-rate encoding is required and the nearest-neighbors search algorithm is one of the




(a) (b)

0- Layer0 search location (predicted motion vector)
1- Layer1 search location
2- Layer2 search location

(a) Nearest Neighbors Search Area
(b) Nearest Neighbors Search Example

Fig 2. Nearest Neighbors Search Algorithm

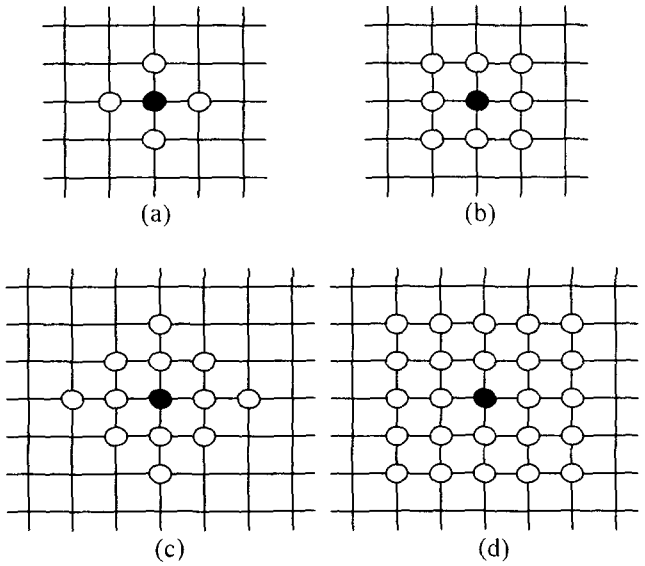
fast search algorithms. As shown in Figure 2, the SAD value from the original pel is computed for 4 pels of the

diamond shaped area. This procedure is repeated until the minimum SAD value is acquired. This method may easily get into local minima. But, it can effectively reduce computing time without much degrading video quality in some applications without much motion changes such as video conferencing.

In case of much motion changes, intra frame encoding can compensate degradation of video quality. As a search origin, using the median value of motion vectors of previous macro blocks instead of zero vector can improve the search accuracy. To improve video quality that is one important drawback of the nearest-neighbors method, many other methods are developed.

## III. The Proposed Search Algorithm

This paper proposes a modified nearest-neighbors search using a double rectangular shaped search area to improve video quality without much increasing search time. The proposed model is evaluated and compared with other models that use various shaped candidate search areas as shown in Figure 3. The figure 3.a shows simple square model and figure 3.b and 3.c show double diamond shaped search area and the proposed model respectively. A simple diamond shaped search area model is adopted as a fast search algorithm in H.263 and the double diamond shaped model was evaluated in [4].




(a) Simple Diamond shaped Search Area
(b) Simple Rectangular shaped Serch Area
(c) Double Diamond shaped Search Area
(d) Double Rectangular shaped Serch Area

Fig 3. Search Candidate Area

## IV. Simulation and Results

The proposed model is simulated using Telenor TMN5 version 2.0 H.263 codec. QCIF format images are used for test images, and the Foreman picture and the Carphone picture are evaluated for the case of motional picture and less motional picture respectively. Test pictures are encoded with 20 frames per second and 32Kbps rate. For experiments, average PSNR, PSNR of each frame, total encoding time, and the amount of computing are investigated for total 150 frames .

Table 1 shows simulation results. Average PSNR of the double rectangular shaped model shows 0.05dB(Carphone) and 0.17dB(Foreman) differences compared with full search algorithm and shows better performance of 0.03dB(Carphone) and 0.13dB(Foreman) compared with the simple diamond shaped model. The encoding time for 150 frames is shown in Table 2. The full search algorithm provides the best performance in video quality and the simple diamond shaped model achieves the fastest encoding time.

| Search Areas | Average PSNR (carphone.qcif) | Average PSNR (foreman.qcif) |
|---|---|---|
| Full Search | 34.51 | 31.32 |
| Simple Diamond | 34.43 | 31.02 |
| Simple Rectangular | 34.44 | 31.08 |
| Double Diamond | 34.45 | 31.12 |
| Double Rectangular | 34.46 | 31.15 |

Table 1. Comparison Average PSNR of Search Algorithms

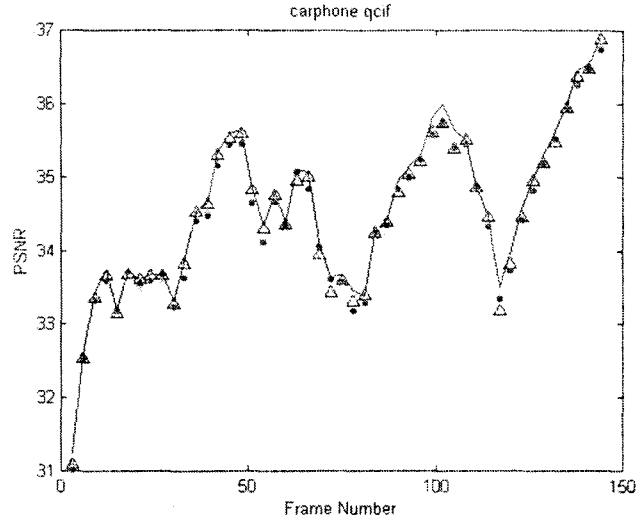
| Search Areas | Encoding Time (carphone.qcif) | Encoding Time (foreman.qcif) |
|---|---|---|
| Full Search | 27.47sec | 30.20sec |
| Simple Diamond | 11.87sec | 12.24sec |
| Simple Rectangular | 12.85sec | 13.12sec |
| Double Diamond | 14.07sec | 14.39sec |
| Double Rectangular | 15.16sec | 15.56sec |

Table 2. Comparison 150 frame Encoding Time

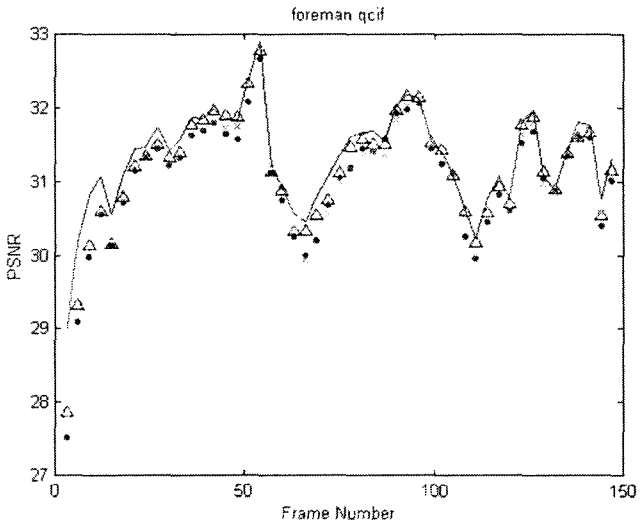
| Search Areas | Computation (carphone.qcif) | Computation (foreman.qcif) |
|---|---|---|
| Full Search | 8.59E+09 | 8.59E+09 |
| Simple Diamond | 1.98E+08 | 2.05E+08 |
| Simple Rectangular | 2.17E+08 | 2.30E+08 |
| Double Diamond | 2.92E+08 | 3.11E+08 |
| Double Rectangular | 3.34E+08 | 3.57E+08 |

Table 3. Comparison Computation of Search Algorithms

Computation of Absolute, sum, and subtraction in processing motion estimation is shown in Table 3




(a)Carphone picture




(c) Foreman picture

-- : Full Search O : Simple Diamond
X : Simple Rectangular + : Double Diamond
Δ : Double Rectangular

Fig 4. Comparison of Search Algorithms

## V. Conclusions

In this paper, a modified nearest-neighbors model that uses double rectangular search area is proposed. Simulation results show that a simple diamond shaped model provides the best performance in encoding time with a little degrading of video quality.

The full search algorithm suffers from the slow encoding time and the proposed model show better video quality than that of the simple diamond shaped model. The proposed model achieves almost half encoding time compared to the encoding time of the full search algorithm.

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