Advances in Intelligent Systems and Computing

Volume 1261

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Proceedings of the International Conference on Advanced Intelligent Systems and Informatics 2020
This volume constitutes the refereed proceedings of the 5th International Conference on Advanced Intelligent Systems and Informatics (AISI 2020), which took place in Cairo, Egypt, during October 19–21, 2020, and is an international interdisciplinary conference covering research and development in the field of informatics and intelligent systems. In response to the call for papers for AISI 2020, 113 papers were submitted for the main conference and 57 for three special sessions, so the total is 170 papers submitted for presentation and inclusion in the proceedings of the conference. After a careful blind refereeing process, 79 papers were selected for inclusion in the conference proceedings. The papers were evaluated and ranked on the basis of their significance, novelty, and technical quality by at least two reviewers per paper. After a careful blind refereeing process, 79 papers were selected for inclusion in the conference proceedings. The papers cover current research intelligent systems, deep learning technology, document and sentiment analysis, blockchain and cyber-physical system, health informatics and AI against COVID-19, data mining, power and control systems, business intelligence, social media and digital transformation, robotic, control design, and smart systems. We express our sincere thanks to the plenary speakers, workshop chairs, and International Program Committee members for helping us to formulate a rich technical program. We would like to extend our sincere appreciation for the outstanding work contributed over many months by the Organizing Committee: local organization chair and publicity chair. We also wish to express our appreciation to the SRGE members for their assistance. We would like to emphasize that the success of AISI 2020 would not have been possible without the support of many committed volunteers who generously contributed their time, expertise, and resources toward making the conference an unqualified success. Finally, thanks to Springer team for their support in all stages of the production of the proceedings. We hope that you will enjoy the conference program.
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Intelligence and Decision Making System
A Context-Based Video Compression: A Quantum-Inspired Vector Quantization Approach

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Abstract. This paper proposes a modified video compression model that optimizes vector quantization codebook by using the adapted Quantum Genetic Algorithm (QGA) that uses the quantum features, superposition, and entanglement to build optimal codebook for vector quantization. A context-based initial codebook is created by using a background subtraction algorithm; then, the QGA is adapted to get the optimal codebook. This optimal feature vector is then utilized as an activation function inside the neural network’s hidden layer to remove redundancy. Furthermore, approximation wavelet coefficients were lossless compressed with Differential Pulse Code Modulation (DPCM); whereas details coefficients are lossy compressed using Learning Vector Quantization (LVQ) neural networks. Finally, Run Length Encoding is engaged to encode the quantized coefficients to achieve a high compression ratio. As individuals in the QGA are actually the superposition of multiple individuals, it is less likely that good individuals will be lost. Experiments have proven the system’s ability to achieve a higher compression ratio with acceptable efficiency measured by PSNR.

Keywords: Video compression · Neural Network · Quantum Genetic Algorithm · Context-based compression

1 Introduction

The immense use of multimedia technology during the past decades has increased the demand for digital information. This enormous demand with a massive amount of data made the current technology unable to efficiently deal with it. However, removing redundancies in video compression solved this problem [1]. Reducing the bandwidth and storage capacity while preserving the quality of a video is the main goal for video...
Compression techniques are divided into two types, lossless and lossy compression.

Nevertheless, there are still many problems or challenges that hinder video compression from being popular. The main issue is how to make a tradeoff between the video quality in terms of Peak Signal to Noise Ratio (PSNR) and the compression ratio. Moreover, researchers sometimes are not able to reach applicable perceptual compression techniques because of application- and context-based quality expectations of users. Nevertheless, perceptual video compression has great potential as a solution to facilitate multimedia content management due to its efficiency for data rate reduction [2]. Recently, several approaches have been presented that attempt to tackle the above problems. The taxonomy of these approaches can be categorized as spatial, temporal, statistical, and psycho-visual redundancies. Readers looking for more information regarding these types can refer to [3]. In general, spatial redundancies can be exploited to remove or reduce higher frequencies in an effective way without affecting the perceived quality.

Vector Quantization (VQ) is an efficient and easy technique for video compression. VQ includes three main steps, encoding, codebook generation, and decoding; see [3] for more information. Neural Network (NN) is commonly used in video coding algorithms [4] that is made of two main components, spatial component, and reconstruction component, the spatial encodes intra-frame visual patterns. The reconstruction aggregates information to predict details. Some of these algorithms can better exploit spatial redundancies for rebuilding high-frequency structures by making the spatial component deep. The neural video compression method based on the predictive VQ algorithm requires the correct detection of key frames in order to improve its performance. Recently, evolutionary optimization techniques (e.g., genetic algorithm, and swarm intelligence) are exploited to enhance the NN learning process and build an intelligent vector quantization [5].

Quantum computation is an interdisciplinary science that emerged from information science and quantum science. Quantum Genetic Algorithm (QGA) is an optimization technique adapted to the Genetic Algorithm (GA) to quantum computing. They are mainly based on qubits and state superposition of quantum mechanics. Unlike the classical representation of chromosomes (binary string, for instance), here they are represented by vectors of qubits (quantum register). Thus, a chromosome can represent the superposition of all possible states [6]. Some efforts were spent to use QGA for exploring search spaces for finding an optimal solution [7, 8]. The codebook design is a crucial process in video compression and can be regarded as a searching problem that seeks to find the most representative codebook which could correctly be applied in the video compression.

1.1 Novelty and Contribution

The novelty of the proposed video compression model is that it is done based on removing different types of redundancies in one package. The model handles the frame’s spatial redundancy by dropping the duplicate in the high-frequency coefficients of the Discrete Wavelet Transform (DWT) through adapting vector quantization based NN, whereas the redundancy inside the low-frequency (high energy) coefficients will
be eliminated by using DPCM. The model controls the enter-frames temporal redundancy by utilizing a background subtraction algorithm to extract motion objects within frames to generate the condensed initial codebook. Regarding statistical redundancy, the model employs run-length encoding to increase the compression ratio. Overall, the model performance depends mainly on the construction of the optimal codebook for vector quantization. It exploits QGA with a fitness function based on the Euclidean distance between the initial codebook and each frame in the video. Utilizing QGA helps in that the effective statistical size of the population appears to be increased. This means that the advantage of good building blocks has been magnified with the aim of enhancing the optimal features selection process [8].

2 Literature Survey

Research in the video compression domain has attracted tremendous interest in recent years. This is mainly due to its challenging nature in effectively satisfying high compression ratio and quality after decoding without degradation of the reconstructed video. An insight into the penitential of using vector quantization for real-time neural video codec is provided in [4]. This technique utilizes Predictive Vector Quantization (PVQ) that combines vector quantization and differential pulse code modulation. Another work involving hybrid transformation-based video compression may be seen in [1]. The hybrid compressed frame is quantized and entropy coded with Huffman coding. This method utilized the motion vectors, found from estimation using adaptive root pattern search, and is compensated globally. Their system was more complex because the hybrid transforms with quantization needs a lot of time to compress the video.

With this same objective, in 2015, Elmolla et al. [1] introduced run-length and Huffman coding as a means of packaging hybrid coding. This type of compression has the ability to overcome the drawbacks of wavelet analysis, but there are some of the limitations, they are not optimal for the sparse approximation of curve features beyond-singularities. More formal description, as well as a review of video compression based on Huffman coding, can be found in [9]. Yet, Huffman coding requires two passes. The first pass is used to build a statistical model of the data, whereas the second pass is used to encode it, so it is a relatively slow process. Due to that, some other techniques are faster than Huffman coding when reading or writing files.

A lot of research interest is being shown in optimization techniques that can obtain the temporal redundancy that deals with motion estimation and compensation based on edge matching, which can alleviate the problem of local minima and, at the same time, reduce computational complexity [10]. The ant colony edge detector is used to create edges for motion compensation. The main disadvantages of block matching are the heavy computation involved and the motion averaging effect of the blocks. Another approach was proposed by Rubina in 2015 [11], defining a technique to provide temporal–based video compression based on fast three-dimensional cosine transform.

To minimize the influence caused by the hybrid transformation in terms of compression quality and increase the compression ratio; Esakkirajan et al. [12] incorporated the advantages of multiwavelet coefficients, possesses more than one scaling function,
and adaptive vector quantization scheme, the design of the codebook is based on the
dynamic range of the input data. Another approach was suggested by Nithin et al. in
2016 [13]. It defined a technique to provide component-level information to support
spatial redundancy reduction based on properties of fast curvelet transform, Burrows-
Wheeler Transform, and Huffman coding from the assembly. Although video com-
pression has been studied for nearly many decades, there is still room to make it more
efficient and practical in the real application. According to the aforementioned review,
it can be found that past studies were primarily not addressing the issues associated
with the building of codebook for vector quantization compression algorithms (most
often built randomly). However, to the best of our knowledge, little attention has been
paid to devising new optimal codebooks and improving its efficiency for vector
quantization.

3 Methodology

This paper proposes a new model that combines the two types of video coding: intra-
frame and inter-frame coding in a unified framework to remove different types of
redundancies (spatial, temporal, and statistical). The intra-frame coding is achieved by
fusing the information come from both of wavelet transform and quantization informa-
tion, the wavelet transform decorrelates the pixels of the input frame, converting
them into a set of coefficients that can be coded more efficiently than the original pixel
values themselves. In contrast, the quantization information originates from DPCM that
forms the core of essentially all lossless compression algorithms. For inter-frame
coding, the vector quantization technique is adapted based on the background sub-
traction algorithm to condense the codebook length. Finally, Run Length Encoding
(RLE) algorithm is used to merge information for the two coding techniques to achieve
high compression by removing the statistical redundancy. Figure 1 shows the main
model components for both compression and decompression phase, respectively, and
how they are linked to each other.

![Flow diagram of the proposed system](image-url)

**Fig. 1.** Flow diagram of the proposed system: (Left) compression phase. (Right) Decompression phase
**Step 1: Generate Initial Codebook:** In this step, a codebook for each video is built offline that relies on extracting the moving parts of the frames (foreground) beside the background; each of them is represented as a codeword. The separating of moving objects is performed based on the background subtraction technique. Background subtraction is a widely used approach for detecting moving objects in videos from static cameras [14]. The accuracy of this approach is dependent on the speed of movement in the scene. Faster movements may require a higher threshold [3].

**Step 2: Codebook Optimization:** Given the initial codebook, the next step is to tune the codewords inside the codebook is given a specific objective function. The quantum genetic algorithm is adopted here to realize this step; the domain of QGA is optimization problems where the set of feasible solutions is discrete or can be reduced to a discrete one, and the goal is to find the best possible solution [6–8, 15]. The structure of a QGA is illustrated in Fig. 2. The suggested model utilizes the quantum parallelism that refers to the process of evaluating a function once on a “superposition” of all possible inputs to produce a superposition of all possible outputs. It means that the time required to calculate all possible outputs is the same time required to calculate only one output with a classical computer. Quantum register with superposition can store exponentially more data than a classical register of the same size. In the quantum algorithm, superimposed states are connected by a quantum connection called Entanglement. In general, quantum superposition gives quantum algorithms the advantage of has less complexity than its classic equivalent algorithm.

![Diagram](image)

**Fig. 2.** QGA structure (left) flowchart, (right) pseudocode
A chromosome is simply a vector of m qubits that forms a quantum register. Herein, the easiest way to create the initial population (a combination of different codewords) is to initialize all the amplitudes of qubits by the value \( \frac{1}{\sqrt{2}} \). All quantum superposition states will be expressed by a chromosome with equal probability. In order to make a reproduction, the evaluation phase quantifies the quality of each quantum chromosome in the population. The evaluation is based on an objective function (Euclidean distance in our case) that corresponds to each individual, after measuring an adaptation value. It permits to mark individuals in the population. In order to exploit effectively superposed states of qubits, each qubit must be observed, known as measuring chromosomes, which leads us to extract a classic chromosome.

In order to intensify the search and improve performance, the interference operation allows modifying the amplitudes of individuals by moving the state of each qubit in the sense of the value of the best solution. This can be made by using a unit transformation that allows a rotation whose angle is a function of the amplitudes and value of the corresponding bit in the reference solution. The value of the rotation angle must be chosen so that to avoid premature convergence. It is often empirically determined, and its direction is determined as a function of the values of probabilities where a qubit is in state 0 and state 1.

Quantum genetic uses quantum gates to perform the rotation of an individual’s amplitudes. Quantum gates can also be designed according to practical problems. The qubits constituting individuals are rotated by quantum gates to update the population \( \mathbb{Q}(t) \). The quantum rotating gates are given by the following equation [8]:

\[
\begin{bmatrix}
    a^i_{t+1} \\
    b^i_{t+1}
\end{bmatrix}
= \begin{bmatrix}
    \cos(\Delta \theta_i) & -\sin(\Delta \theta_i) \\
    \sin(\Delta \theta_i) & \cos(\Delta \theta_i)
\end{bmatrix}
\begin{bmatrix}
    a^i_t \\
    b^i_t
\end{bmatrix}
\]

(1)

where \( a^i_t \) and \( b^i_t \) are the probability amplitudes associated with the 0 state and the 1 state of the \( i^{th} \) qubit at time \( t \). Therefore, the values \( a^2 \) and \( b^2 \) represent the probability of seeing a qubit in states 0 and 1 respectively, when the value of the qubit is measured. As such, the equation \( a^2 + b^2 = 1 \) is a physical requirement. Where \( \Delta \theta_i \) is the rotation angle of qubit quantum gate \( i \) of each quantum chromosome. It is often obtained from a lookup table to ensure convergence, as illustrated in Table 1.

**Table 1.** Rotation angle selection strategy

| \( x_i \) | \( b_i \) | \( f(x_i) > f(b_i) \) | \( \Delta \theta_i \) | \( \gamma_m + \beta_m = 0 \) | \( \gamma_m < 0 \) | \( \gamma_m = 0 \) | \( \beta_m = 0 \)
<table>
<thead>
<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>True</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>False</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>True</td>
<td>1</td>
<td>(-1)</td>
<td>0</td>
<td>(\pm 1)</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>False</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>True</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
The increase in the production of a good building block seems to be the most significant advantage of QGA. The promotion of good building blocks in the classical GA is statistically due to their ability to produce fit offspring, which will survive and further deploy that building block. However, when a new building block appears in the population, it only has one chance to ‘prove itself’. By using superimposed individuals, the QGA removes much of the randomness of the GA. Thus, the statistical advantage of good building blocks should be much greater in the QGA. This, in turn, should cause the number of good building blocks to grow much more rapidly. This is clearly a very significant benefit [6–8].

3.1 Compression

Data compression schemes design involves trade-offs among the compression rate, the distortion rate (when using lossy data compression), and the computational resources required to compress and decompress the data [1, 2]. The compression phase consists of two main stages, lossless compression based on DPCM and lossy compression based on an enhanced Learning Vector Quantization (LVQ) neural network. Both stages operate on wavelet coefficients of each frame [16].

(a) Lossless Compression: for each frame, the low-frequency wavelet coefficients with a large amount of energy are losslessly compressed to preserve the most important features from loss. In this, Differential Pulse Code Modulation DPCM is employed as a signal encoder that uses the baseline of pulse-code modulation (PCM) but adds some functionality based on the prediction of the samples of the signal [16]. DPCM takes the values of two consecutive samples; if they are analog samples, quantize them; calculate the difference between successive values; then, get the entropy code for the difference. Applying this process, eliminated the short-term redundancy (positive correlation of nearby values) of the signal.

(b) Lossy Compression: for each frame, the high-frequency wavelet coefficients with a small amount of energy (not salient features) are lossy compressed to achieve a high compression ratio. In this LVQ neural network are adapted to compress these coefficients; LVQ neural network utilizes an optimized codebook for each video as a dynamic vector quantization to be embedded into the hidden layer as an activation function. Unlike the current methods that employed the neural network as a black-box for lossy compression, the suggested model adapts optimized VQ derived from step 2 as an activation function embedded in each hidden layer’s neurons.

(c) Run Length Coding: given both of the quantized coefficients vector obtained from the DPCM lossless compression stage and VQ index vector obtained from the LVQ neural network lossy compression stage, the two vectors are merged into a unified vector with specific delimitation between them for decoding. In this case, there exists one unified vector for each frame. To increase the compression ratio, RLE is utilized to handle statistical redundancy among unified vector elements [1].
3.2 Decompression

The decompression process is done in a reverse way to the compression process, as illustrated in Fig. 1 that includes the following steps. First, apply run-length decoding to each row of the matrix $V_r$ that contains the compressed video to retrieve the merged coefficients vector $f_r$. This vector comprises the quantized coefficients $L_{Lc}$ and VQ index vector $I_{dx}$ for each frame. Then for the quantized coefficients $L_{Lc}$, apply inverse DPCM to obtain the un compressed coefficients (low frequencies) $LL$. For the given VQ index vector $I_{dx}$, by utilizing the stored codebook table, this index value is converted to the equivalent vector to retrieve the high-frequency coefficients (each frame has one vector that contains $HL$ coefficients). Given $LL$ and $HL$ from the previous steps, these bands are combined with their other two unaltered bands ($LH$, $HH$) that given from the database and utilizing inverse DWT to get the decompressed frame. Repeat the previous steps for all rows in the compressed matrix $V_r$; collect the frames for retrieving the original video.

4 Experimental Results

Experiments were conducted on a benchmark video dataset (available at http://www.nada.kth.se/cvap/actions/ and https://media.xiph.org/video/derf/). The testbed is a set of videos with different resolutions, different numbers of frames, and various extensions like avi and mpeg. The testbed includes eight videos, as shown in Fig. 3. Herein, the background for all these videos is unmovable, while their foreground is varying from near stability like Miss America to movement like Aquarium. In this paper, the suggested intelligent vector quantization model that relies on quantum genetic algorithm has been tested with several benchmark videos. The parameter values were chosen according to the most values found in the literature [6, 8, 15].

The first set of experiments was performed to compare both of compression ratios and quality performance of the proposed model that utilizes the quantum genetic algorithm to build optimal codebook for vector quantization that is used as an activation function inside neural network’s hidden layer with LBG-based video compression technique (without QGA) that relies on the randomness to build the codebook. As shown in Table 2, using QGA achieves an improvement of about 6% in the compression ratio and 8% in PSNR compared with the LBG video coding technique. Furthermore, QGA achieves better results with about 0.2% compared to traditional GA. Figure 4 shows the visual difference between the original and the reconstructed video’s frame.
**Fig. 3.** Benchmark dataset

<table>
<thead>
<tr>
<th>Video</th>
<th>Random codebook method (LBG)</th>
<th>Codebook generation with GA</th>
<th>Codebook generation with QGA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CR</td>
<td>PSNR</td>
<td>CR</td>
</tr>
<tr>
<td>Man running</td>
<td>30.365</td>
<td>37.547</td>
<td>32.512</td>
</tr>
<tr>
<td>Traffic road</td>
<td>29.354</td>
<td>27.241</td>
<td>30.665</td>
</tr>
<tr>
<td>Aquarium</td>
<td>28.968</td>
<td>28.248</td>
<td>30.552</td>
</tr>
<tr>
<td>Akiyo</td>
<td>28.785</td>
<td>27.954</td>
<td>30.512</td>
</tr>
<tr>
<td>Miss America</td>
<td>28.417</td>
<td>40.696</td>
<td>30.512</td>
</tr>
<tr>
<td>Boxing</td>
<td>29.657</td>
<td>37.857</td>
<td>30.512</td>
</tr>
</tbody>
</table>
An advantageous point of a QGA is its ability to find a globally optimal solution in multidimensional space. This ability is also useful for constructing an optimal codebook of VQ for video compression. This means that we can obtain a better quality of a representative codebook. The reason for the low compression ratio is that the proposed model utilizes the lossless compression to compress a large number of important coefficients. In general, in the case of a small number of elements within the quantization vector, both algorithms were equivalent for all problem instances. However, augmenting the number of items leads QGA to behave better than GA, and this in all problem solution variants.

The next experiment shows the comparison of the proposed model with other related video compression systems. The first comparative algorithm [10] utilized a motion estimation technique based on ant colony and modified fast Haar wavelet transform to remove the temporal redundancy. The second algorithm [1] employed fast curvelet transform with run-length encoding and Huffman coding to remove spatial redundancy. On the contrary, the proposed model removes both of temporal redundancy by utilizing optimal vector quantization, spatial redundancy by employing DPCM, and finally statistical redundancy by implementing run-length encoding.

Both of Table 3 and Table 4 shows that the proposed model gives better results in terms of PSNR of the reconstructed video of about 23% improvement as compared to the first algorithm, and 3% improvement as compared to the second system. In addition, the proposed model improves the compression ratio by 22% as compared to the second system. The rationale of these results is that using QGA helps to build an accurate codebook with minimum distortion for the vector quantization technique. Furthermore, using RLE for statistical redundancy removing beside DPCM and vector quantization yields more CR as compared with the second algorithm.

![Fig. 4. (a) Original frame. (b) Reconstructed frame (PSNR = 31.810)](image-url)

<table>
<thead>
<tr>
<th>Video</th>
<th>A. Suri et al. method [10]</th>
<th>Proposed model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PSNR</td>
<td>PSNR</td>
</tr>
<tr>
<td>Tennis</td>
<td>30.438</td>
<td><strong>38.347</strong></td>
</tr>
<tr>
<td>Suzie</td>
<td>34.5746</td>
<td><strong>42.908</strong></td>
</tr>
</tbody>
</table>

Table 3. Comparative result with optimized technique.
In video compression, designing a codebook can be regarded as an optimization problem; its goal is to find the optimal solution, which is the most representative codebook [5]. It is assumed that the QGA-based vectors are mapped to their nearest representative in the codebook with respect to a distortion function i.e., more PSNR. QGA is applied by different natural selection to find the most representative codebook that has better fitness value in video compression. To expedite evolution and prevent the solution from getting out of searching space, tuning crossover and mutation ratio are firstly explicitly determined.

Moreover, quantum algorithms generally have the ability to minimize the complexity of equivalent algorithms that run on classic computers. Regarding the global complexity, the global complexity for QGA (Evaluation + Interference) is of the order of $O(N)$, while for a standard GA (Evaluation + Selection + Crossover + Mutation) the global complexity is often of the order of $O(N^2)$, where $N$ is the size of the population. Therefore, we assure that this result is very encouraging since the complexity here has been reduced to become linear. Indeed, one can imagine what happens if we consider a very large population of chromosomes; it will be very useful to use QGA instead of GA.

There are some potential difficulties with the QGA presented here, even as a theoretical model that includes: (1) some fitness functions may require “observing” the superimposed individuals in a quantum mechanical sense. This would destroy the superposition of the individuals and ruin the quantum nature of the algorithm. (2) The difficulty of reproduction is more fundamental. However, while it is not possible to make an exact copy of a superposition, it is possible to make an inexact copy. If the copying errors are small enough, they can be considered as a “natural” form of mutation [6–8].

### 5 Conclusion

Like most other problems, the design of suitable video compression strength involves multiple design criteria and specifications. Finding optimal codebook in vector quantization, not a simple task. Consequently, there is a need for optimization-based methods that can be used to obtain an optimal solution that would satisfy the requirements. Ideally, the optimization method should lead to the global optimum of the objective function. In the work presented in this paper, QGA has been used to achieve an optimal solution in the multidimensional nonlinear problem of conflicting nature (high compression ratio with an acceptable quality of the reconstructed video).

<table>
<thead>
<tr>
<th>Video</th>
<th>A. Elmolla method [1]</th>
<th>Proposed model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CR</td>
<td>PSNR</td>
</tr>
<tr>
<td>Traffic road</td>
<td>25.11</td>
<td>31.08</td>
</tr>
<tr>
<td>Aquarium</td>
<td>24.93</td>
<td>30.64</td>
</tr>
</tbody>
</table>

Table 4. Comparative result with traditional technique for video coding.