FPGA Implementation of Intra Frame for H.264/AVC Based DC Mode

Dr. Mohammed H. Al-Jammas¹ and Mrs. Noor N. Hamdoon²

¹ Ninevah University, College of Electronics Eng., Computer and Information Eng. Dep., Mosul, Iraq.
² University of Mosul, College of Engineering, Electrical Eng. Dep., Mosul, Iraq.

¹dr_mohammed_al_jammas@uomosul.edu.iq, ²noornawaf81@yahoo.com

ABSTRACT
A Hybrid encode standard H264/AVC is the strongest and most standard encode advanced in encode and data processing used in data compression systems. Modern so as to what possessed of strength and flexibility in the encode of data to be moved, because of platforms used in most applications, in this paper the System intra frame encode and data compression for single works to encrypt and decode the encrypted data display of all kinds of different that the target of the message implementation of all components of the encrypted and encode emulate a practical on-chip FPGA, represented by the implementation of encode and decode the Intra frame algorithm within the time frame (1.294 ms) with frame size (120x160) and consumption of approximately (3714) slides to implement all components of the encoder (integer conversion function, function approximation, inverse transfer function, inverse function approximation), 92% of the chip size within the frequency 68MHZ within the programmer of practical applications ISE version 14.1 company Xilinx and chip Spartan3E (XC3S500E). Note the implementation time can work in real time to encode and decode the videos.

Keywords: H264/AV, Intra frame (I-frame), DC Mode.

1. INTRODUCTION
Before evolving the electronic displays (analog TV) has very few channels and operate within limited bandwidth. And do not talk only projector only, as well as mobile phones were used to make voice calls or send SMS (short message service), as well as special services for communication via the World Wide Web (the Internet) with limited capabilities and speed are linked mostly via telephone connection (modem). In the early days of the fast development in the past decade, tremendous innovations communication systems and technology have transformed the world into a "digital age" or the "electronic age", in this era of mobile phones called smart phones, if the work is not restricted to only calls but used to browse the Internet, send emails, watch videos, and transfer data, navigation, camera as well as display devices are called digital projectors and have more features with regional channels and international quality (High definition) HD[1].

There are many video data compression standards, Joint Photographic Experts Group (JPEG), motion picture experts group (MPEG) of the International Organization for Standardization (ISO) and International Electro technical Commission (IEC), including the standard JPEG and JPEG 2000, this cooperation resulted in the creation of a standard known as H.264/AVC or MPEG-4 for video compression [2].

H.264/AVC intra encoding achieve higher compression ratio and picture quality compared with the latest still image coding standard JPEG2000).intra prediction is the first process of advanced video coding standard. It predicts a macro block by referring to its previous macro blocks to reduce spatial redundancy. Intra prediction supports nine modes for 4x4 block and four modes for 16x16 blocks [3].

H.264 is an open, licensed standard that supports the most efficient video compression techniques available today. Without compromising image quality, an H.264 encoder can reduce the size of a digital video file by more than 80% compared with the Motion JPEG format and as much as 50% more than with the MPEG-4 Part 2 standard. This means that much less network bandwidth and storage space are required for a video file. Or seen another way, much higher video quality can be achieved for a given bit rate [4].

2. THE ENCODING PROCESS
H.264 encoder works on the same principles as that of any other codec. Fig. 1 shows the basic building blocks of H.264 video codec.

The input to the encoder is generally an intermediate format stream, which goes through the prediction block; the prediction block will perform intra and inter
prediction (motion estimation and compensation) and explore the redundancies that exist within the frame and between successive frames. The output of the prediction block is then transformed and quantized. An integer approximation of the discrete cosine transform is used (DCT) for transformation. It uses 4x4 or 8x8 integer transform, and outputs a set of coefficients each of which is a weighted value for a standard basis pattern. The coefficients are then quantized i.e. each coefficient is divided by an integer value. Quantization reduces the precision of the transform coefficients according to the quantization parameter (QP). Typically, the result is a block in which most or all of the coefficients are zero, with a few non-zero coefficients. Next, the coefficients are encoded into a bit stream. The video coding process creates a number of parameters that must be encoded to form a compressed bit stream[4]. These values include:

- Quantized transform coefficients.
- Information to re-create prediction.
- Information about the structure of compressed data and the compression tools used under encoding.

Video compression is about reducing and removing redundant video data so that a digital video file can be effectively sent and stored. The process involves applying an algorithm to the source video to create a compressed file that is ready for transmission or storage. To play the compressed file, an inverse algorithm is applied to produce a video that shows virtually the same content as the original source video. The time it takes to compress, send, decompress and display a file is called latency. The more advanced the compression algorithm, the higher the latency, given the same processing power. A pair of algorithms that works together is called a video codec (encoder/decoder) as shown in Fig.(2,3).

4. H.264 LEVELS

The Group focused joint development in determining work H.264 to find a solution is simple and flexible could include various applications through the use of a single standard, as is the case in video standards, etc., and is this flexibility in the provision of facilities for several profiles (represented groups of algorithms for the pressure data) and levels (level private suite of applications). The standard includes the following seven sets of capabilities, which are referred to as profiles, targeting specific classes of applications: Baseline profile (BP), Main Profile (MP), Extended Profile (XP), High Profile (HiP), High 10 Profile (Hi10P), High 4:2:2 Profile (Hi422P), and High 4:4:4 Predictive Profile (Hi444PP).
5. INTRA FRAME

H.264 consists of several different types of frames, such as (I-P-B), and can be used for encryption to get the required efficiency below illustrate the theoretical formula for each quality of frames.

(I-intra frame ) Is an autonomous framework which can encrypt and decrypt independently without need for another picture as a source of information retrieval, the (I-frame) is the starting point for the video display as well as his importance in information retrieval synchronization if any damage in transport stream bit (bit stream), the flaw in this window that consumes the largest possible number of bits for encryption because it takes the window image full but on the other hand, the error rate is low. Encryption method for this type of window has two properties, depending on the method of dividing the cluster either ((16x16) or (4x4)) but in General is to convert the frame version (RGB)format (YCbCr) and separated from the other components of the final representation and is treated with a single image, so the representation of video format ((4:2:0) YCbCr) is to reduce the sensitivity of the eye where the eye responds to brightness by colors so the component (Y) represents the symbol of brightness luminance while (CbCr) represents the color (chrominance) taken the element Y with full size while the rest of the elements are reduced by deciding to half the amount of action in the element size (Y) is (16x16) , the rest of the elements are the size of (8x8), this means that embedded type of encryption key encryption process. Encryption process as previously mentioned it is dependent on frame division, divides the frame into multiple blocks of size (16x16) and has (4) types of encryption as shown in Fig. 4.

But the case of the split window to (4x4) , it has (9) types, as in Fig. 5

In 4x4 Intra prediction modes, the values of each 4x4 block of luma samples are predicted from the neighbouring pixels above or left of a 4x4 block, and nine different directional ways of performing the prediction can be selected by the encoder as illustrated in Fig. 3 and Fig. 4. Each prediction direction corresponds to a particular set of spatially-dependent linear combinations of previously decoded samples for use as the prediction of each input sample. Fig. 6 shows block of pixels a, b, c ... p, belonging to a macro block to be coded. Pixels A, B, C ...H and I, J, K, L, M are already decoded neighbouring pixels used in the computation of prediction of pixels of current 4x4 block [4].

6. TRANSFORM, QUANTIZATION FOR INTRA FRAMES

The residual macroblock X is transformed using 4x4 Integer Transform .This transform is based on the DCT with some fundamental differences [5, 6]. The 4x4 DCT of an input array X is given by

\[ Y_{DCT} = MXM^T \]
Where \( a = 1/2 \), \( b = 1/2 \cos \pi/8 \) and \( c = 1/2 \cos(3\pi/8) \).

The forward Transform is performed as

\[
Y = (C_f X C_f^T) \otimes E_f \quad (2)
\]

where

\[
C_f = \begin{bmatrix}
1 & 1 & 1 \\
2 & 1 & -1 \\
1 & -1 & -1 \\
-2 & 2 & 1
\end{bmatrix}
\]

\[
E_f = \begin{bmatrix}
ab/2 & ab/2 & ab/2 & ab/2 \\
ab/2 & ab/2 & ab/2 & ab/2 \\
ab/2 & ab/2 & ab/2 & ab/2 \\
ab/2 & ab/2 & ab/2 & ab/2
\end{bmatrix}
\]

The core Transform in Integer transform is given by

\[
Y = (C_f X C_f^T) \quad (3)
\]

The corresponding Inverse Transformation is given by

\[
X' = C_f^T (Y \otimes E_i) C_i \quad (4)
\]

H.264 uses a scalar quantizer and the quantization incorporates the post and pre scaling matrices. The basic forward quantizer operation is as follows:

\[
z_{ij} = \text{round} \left( Y_{ij}/Q\text{Step} \right) \quad (5)
\]

Inverse quantization operation is given by

\[
Y'_{ij} = z_{ij} \times Q\text{Step} \quad (6)
\]

7. THE INTRA FRAME DESIGN FOR STANDARD H264/AVC WITHIN ISE

H.264 encoder device is designed as a model system of small low-power components and specific tasks, and the aim of design is to know the possibility of the encoded for use in the camera that gives less data with good quality. You can add and remove some of the ingredients depending on what application is used, for example, you can remove the adapter the cosine and replaced with integer. The basic outline of the window interface to encryption standard practice shown in Fig. 7.

8. THE RESULTS OF THE ENCRYPTION INTRA FRAME

Architectural engineering design was based on the analysis of cryptographic functions shown in figure (5) and architectural 4x4 interface of forecasting unit minus the absolute as in SAD and module and control unit, the control unit signals (select the frame, and the beginning of the frame, and the rounding signal ...CLk), and generates all the flags for each stage and control signals to communicate with other units.

8.1 Luminance block encryption unit (Luma) block size 4x4

Architectural design interface framework encryption depends on the equations to predict for each pattern, in fact, after careful analysis of the cryptographic interface styles found in practical on FPGA is \( A+B+C+D+I+J+K+L+4 \). Practice in applying the second mode as shown in (Figure 6) before process simulation process all signals the control to read data from external memory must be initialized first slide (new slice) of the image and signal selection the first line (newline) of the slide before the end of the reading of data storage and gives the signal of the (strobe) signal must be formatted with font selection to get accurate results. It may have a delay between data taken from (READYI) external...
memory as a result of these reasons, you should encrypt the entire line at a time and then do the second line.

Fig. 8. practical results to represent the second Mode2 (DC Mode For block size 4x4)

8.2 Forward and Inverse Integer Cosine Transform (ICT & IICT)

The video switched to formula (YCbCr) and the selection of the styles in the framework interconnection luminescent elements is (Y) depends on the block size is chosen to split the window and then choose the style shift remaining elements through cosine conversion function two-dimensional but in practice will face difficulty in application, and turning each block 16x16 of lighting to the 4 x 4 after intervention elements (DC) of the transfer function hadamard and enter items to bring for transactions and transaction encryption blocks in the order indicated from 0 to 15. Fig 9 shows the practical results of the integer conversion function calculated without the multiplication matrix E which will be a bridge with is the input matrix and is the output of the transformation.

Fig. 9. The practical results of the forward integer cosine transform

Inverse transfer function 4X4 integer cosine (IICT) is the very approach to the conversion function integer cosine (ICT), complexity is the same. The results show the process of transfer function in reverse Fig. 10.

8.3 forward and inverse hadmard transform

The second part of the conversion is a conversion function Hadamard-(HT) and apply the elements of the DC from the block and block coloration can be expressed by the equation (7).

\[ Y = H_f X H^T_f \] (7)

Either the inverse transfer function alhadmard Inverse Hadamard Transform (IHT) is similar to the front alhadmard conversion function, because similar matrix, \( H_f \) (Fig. 11) shows the practical consequences of the conversion function alhadmard and (Fig. 12) shows the inverse function alhadmar

Fig. 10. The practical results of the inverse integer cosine transform

Fig. 11. The practical consequences of the conversion function alhadmard

Fig. 12. The practical results of inverse transfer function alhadmard

8.4 Forward and Inverse Quantization (Q & IQ).

In the encryption standard H264/AVC specifies rounding by matrix E above and figure out the equation (2). And rounding mechanism has become more complex in practice, due complicated to try to gain access to integers during the Division and avoid getting a decimal. In order to review the practical results of the front and the reverse zoom function, as shown in Fig. (13,14)

Fig. 13. The practical results of forward quantization

Fig. 14. The practical results of inverse quantization
9. IMPLEMENTATION TOP PROGRAMMER OF THE ENCRYPTION INTRA FRAME FOR STANDARD H264/AVC

Now we show the total for all components of a cryptographic coded field gates to chip spartan3e (xc3s500E) as shown in figure (15) and internal planning for the gates of the encrypted are shown in Fig. (16) as well as the amount of time that represents the real time encryption block size 4x4 shown in figure(14). the implementation of an encryption standard process is to calculate the length of time it takes to implement cryptographic modules as well as the amount of data storage units as shown in the table (1)
REFERENCES


AUTHOR PROFILES:

Mohammed H. AL-Jammas (Jun’02) born in 1966 in Mosul-Iraq. He awarded BSc in Electronic and Communication Engineering from the University of Mosul, Mosul-Iraq in 1988. Next, he awarded the MSc in Communication from the University of Mosul, Mosul-Iraq in 1994, and PhD in Computer Engineering from the University of Technology, Baghdad-Iraq in 2007. From 2002-2006, Dr. Mohammed worked with the University of Technology in Baghdad. From 2007-2016, he acts as an Assistance dean of the College of Electronics Engineering at the University of Mosul. From 2016 he acts an Assistant Prof. in College of Electronics Engineering at the Ninevah University. Through his academic life he published over 8 papers in field of computer engineering, and information security.

Noor N. AL-al-sawaf (August’9) born in 1988 in Mosul-Iraq, she awarded BSc in Electronics Engineering from the University of Mosul, Mosul-Iraq in 2010. Next, she awarded the MSc in Electrical from the University of Mosul, Mosul-Iraq in 2014. Through his academic life she published 2 papers in field of image and video compress.