

Watermarking Video in an Embedded System

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Abstract : As the development in the multimedia sector is growing with very high speed the crimes related to it is also increases due to the ease of reproduction, distribution and manipulation of the digital document. The classical method such as data encryption, copyright protection are not much satisfactory in this matter. Because after decryption one cannot control illegitimate use of it. Usually the copyright concept is bypassed. A secure, imperceptible, robust watermark on the digital document is more helpful to trace the actual owner and authorized person to use it. Watermark is a signal (text or image) embedded in to the host signal with out degrading it. In this paper real time implementation of the watermarking video in an embedded system is discussed. The embedded system used here is the stretch software configurable processor (SCP). Watermark is embedded in spatial and frequency domain. Even-odd watermarking method is used spatial domain and DCT is for frequency domain. Using the compute intensive power of the stretch the watermark is embedding is achieved with out frame skip in real time video also with ISEF, the DCT calculation part giving a performance of 35 times.

Index Terms— Copyright protection, DCT, digital watermark, ISEF, SCP.

I. INTRODUCTION

The digital representation of audio signals, images, video has become more popular due the ease of reproduction transmission and manipulation of it with out any degradation in quality. Though digital representation of analog media introduces lot of benefits, in communication the problems created to the rightful owner is also more. The concepts such as data encryption, copyright protection are not much effective. So one has to find the new technology to defense against the unauthorized use of valuable digital media [1]-[4]. At the right time digital watermarking concept is introduced. Digital watermarking is a technique of embedding the imperceptible information (text or image) in to the host digital document. The imperceptible information is called the watermark. Generally watermarks convey the information about copyright, ownership, timestamps, legitimate user etc.

Mainly the watermarking technique can be implemented in spatial domain and in frequency domain. In case if spatial domain, the watermark modifies the lower order bits of the pixels of an image or video either by replacing or by adding. In frequency domain, the watermark is embedded in the transform domains such as FFT, DCT, DWT. The spatial domain watermarking is simple and faster compared to the compute intensive frequency domain watermarking.

The effective watermark should satisfy the following properties [1], [5].

1. **Robustness :** The watermark should stand even after subjected to attacks such as cropping , resizing, filtering, signal processing and can reliably detectable.
2. **Security:** The location where and how the watermark is embedded should secrete to the end users.
3. **Real time implementation:** For video applications it is required to implement the watermark on-the-fly.
4. **Imperceptibility:** Watermarking process should not degrade the document to ensure the quality even after watermark is embedded.
5. **Asymmetric:** There should not be a reference to the original document or watermarking key to detect the reliably.

To reflect these properties in an embedded system, in part of our work we used stretch software configurable processor (SCP).

The SCP is an development environment which enables the user to configure the embedded hardware using only C/ C++ programming tools to meet the needs such as compute intensive applications in real time.

The advantages of using SCP are as follows.

1. **Design flexibility:** Allows the user to respond the new or evolving standards and features without having to start their system designs over again.
2. **Performance:** The hot-spots (the sequence of operations that are executed repeatedly) expressed in C/C++ are reduced to a single instruction, gaining high performance.
3. **Shorten the development time:** Use of SCP eliminate

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the time for hardware design and time for optimization of an applications.

4. **Lowered system cost:** Use of a single SCP replaces the DSP processors and FPGA's, reducing the manufacturing costs and shrinking the product footprint.

II. MATERIALS AND METHODS

The watermark to embed is the copyright information and is a text document. The ASCII representation [4] of the watermark is obtained and is used to embed in the host, streaming real time video. In case of spatial domain watermarking we choose an even-odd watermarking method. Here the least significant bit of the pixel of the host video is replaced according the watermark bit to be embed. We used discrete cosine transform (DCT) domain to embed the watermark in the frequency domain. Here the DCT for 8x8 block is find out and the watermarking information is embedded depending on the transformed value of adjacent pixels considered for watermarking. The process is repeated until the DCT calculation covers one full input frame coming out of video source. The following sub sections describe the basic materials used and then how the selected algorithms are implemented in using these materials on the embedded system (SCP).

A. The stretch video development platform.

The stretch's video development platform is an environment that provides the developer a method to input and output the real time video with some compute intensive operations being processed on it. It is composed of 2 components a hard ware component and a software component. The hardware component includes a stretch software configurable processor s55DB30 and a audio video module(AVM) daughter card. Software component consist an Integrated development Environment (IDE), and other API's packages to configure the respective FPGA's in audio video module daughter card. AVM daughter card supports composite(CVSB), S-video(YC), and component(YPrPb) input output standards and an interface between it with s55DB30 provides mean of data transfer between the SCP and external world.

Fig. 1 indicates the block diagram of the SCP. It has a wide register file, a static register file, Instruction Specific Extended Fabric (ISEF), on chip data ram etc. The 128 bit wide special registers are used to transfer the data between memory(either external or on chip memory) and ISEF. These registers can hold sixteen 8 bit data values. The processor has four streaming functions; three of these are used to stream data into the ISEF and one is used to stream data i.e. the result out of the ISEF. The ISEF allows all the standard data types; it also allows signed and unsigned integers of variable number of bits. To achieve the better performance the the contents of the external memory is transferred to the on chip memory using memory management unit(MMU).

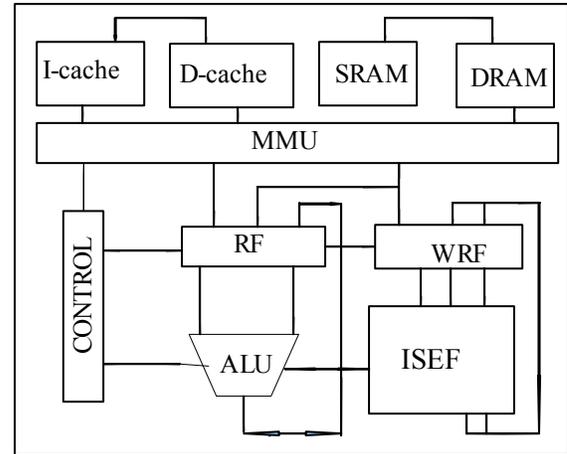


Fig. 1 Block Diagram of SCP

B. Implementation of watermark.

The DVD player is used as the real time video source. The streaming video is read through the audio video module daughter card either in interlaced or in the progressive format. In our work we read the video in the interlaced format. This is then fed to the SCP to perform compute intensive applications. The video in the interlaced format is first converted in to the progressive form using simple deinterlacing technique called weave. The watermark is embedded on this progressive video.

In our work we used watermarking method both in spatial domain and frequency domain. The Fig. 2 indicates the block diagram of the even-odd method of watermarking in spatial domain. First the ASCII equivalent of the watermark is taken and depending on the number of watermark bits, the pixels of input video frame are grouped to get the number of pixels available to embed a single watermark bit. Generally input frames are collected in the external memory. Using DMA channels in the SCP the pixels are grouped and are fed to the high speed on chip memory. Which accelerates the speed of operation.

The pixels present in the local on chip memory then sent to the ISEF using Stretch special instructions though WR's. In ISEF the even -odd watermarking method is implemented on individual pixel values. Here the watermark bit is taken and depending on the value (either 0 or 1) the pixel value is modified to the nearest even or odd number. If the pixel value already satisfying the required criteria then that pixel is not modified. Also during modification it is checked for the overflow and underflow condition of the modified pixel value. During such cases the pixel values are scaled so as to fit with in the range of 0-255. The watermarked pixels are then transferred to the output buffer in the external memory via on-chip memory and DMA channels.

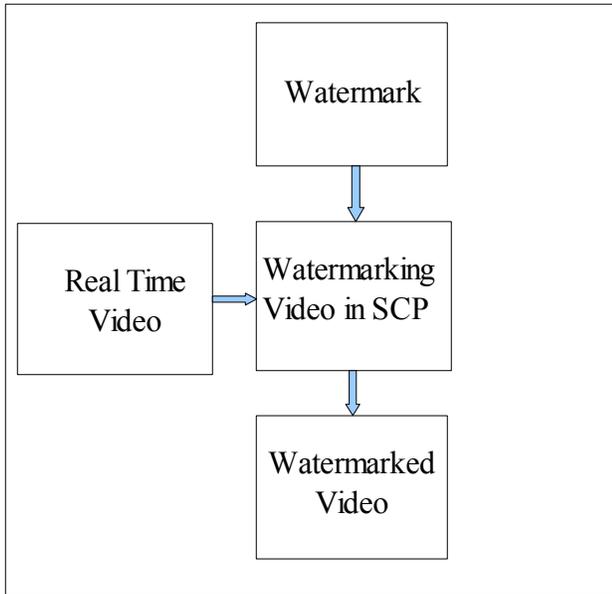


Fig. 2 Even-Odd Watermark Implementation

De-watermarking is done to extract watermark. This is achieved in the similar way how the watermark is embedded. The statistical probability of the individual embedded bits are determined and are grouped to form text information. This matches with the original watermark that is embedded.

The DCT domain is used to watermark the video in frequency domain. Fig. 3 indicates the block diagram of watermarking video in the DCT domain

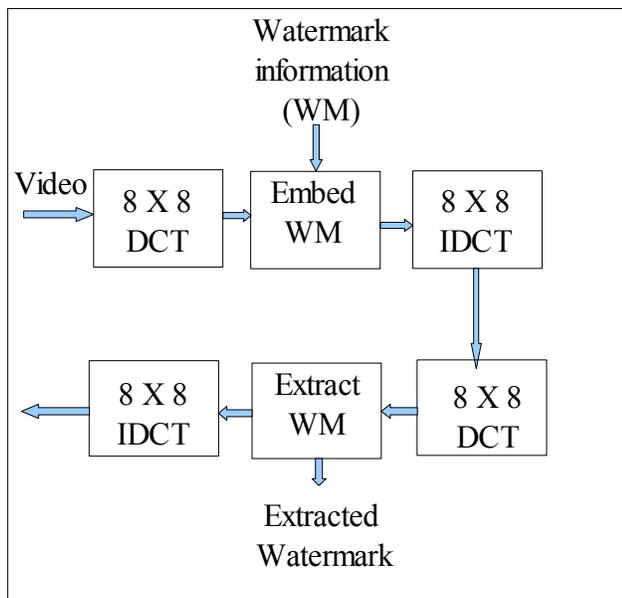


Fig. 3 Block Diagram of watermarking video in DCT domain

The input video frames are collected in the memory buffers. 8 X 8 DCT coefficients are used to transform the pixel values in frequency domain. For this blocks containing 64 pixels are obtained using DMA channels and on-chip memory. After this step the local on-chip memory contains the pixels to which the an 8 X 8 DCT is to be find. First the code to find the DCT for the block of 64 pixels is written in simple C language and is executed with out using the ISEF. The cycle count to perform DCT of one block is noted. The DCT includes compute intensive operations which takes lot of clock cycles to perform operations. Hence the same code is rewritten to use the compute intensive powers of SCP. The block of values are sent to the ISEF and there the DCT is find out. The cycle counts required to find DCT with ISEF is noted. It is found that the DCT calculation of block containing the 64 pixels is with ISEF is nearly 35 times faster than that with out using ISEF.

The watermark bits are then embedded in to this DCT block. A pair of transformed values (t_k, t_l) are taken in diagonal. Depending on the bit to embed the t_k and t_l the must hold a predefined relationship. If the bit is to embed "1" then $t_k \geq t_l$; if bit is to embed "0" then $t_k \leq t_l$. If the required relationship occurred naturally then nothing to do with it else the values are changed accordingly[2]. Then the IDCT is find for the same block and send to the output buffer using DMA channels and on-chip memory. The process is repeats until one full input video frame is considered for the watermarking. Then next frame is taken and watermarked. All the operations are done in sequence on real time video with out any skipping frame.

Since the watermark is embedded in DCT domain the extraction of the same is done at DCT domain itself. Here same procedure of finding DCT is used. The values considered to embed watermark are checked and using statistics the embedded bit is extracted. Such extracted bits are grouped to form a text information.

III. RESULTS AND FUTURE WORK

We done the implementation of watermarking video in an embedded system. This work is done on a video coming out of DVD player considering as real time video. There will not be any frame skip during our implementation. Also for compute intensive DCT calculation we got a performance of 35 times using ISEF over one which is with out using ISEF.

In our part of work we were not take into consideration of possible attacks on the watermarked video. This has to be done in future with still optimization in the existing code.

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