Design and Implementation of Compensated Frame Prediction & Reconstruction

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Abstract – In image and video processing, the estimation of motion plays a vital role in video compression as well as multi-frame image enhancement. Disparate as they may seem, these many applications share one common thread in all such applications, the demand is high for accurate estimates of motion requiring minimal computational cost. This paper presents compensated motion frames prediction and detection using pattern similarity technique. The proposed technique decreases the computation time. This paper uses a technique of pattern similarity based on block based and pixel based approach. In this, various image processing operations are used for frames prediction and its reconstruction. In this, it detects the motion in real time images. An enhancement technique is used for improving the contrast of an image with high value of PSNR. The PSNR values of proposed method are also better than actual one. Also computational time of proposed technique is better than the three step and four step search technique. All simulations are done in MATLAB.

Index Terms – Motion estimation techniques, frames prediction, block based techniques, reconstruction of images.

1. INTRODUCTION

From the last few years, Digital video becomes omnipresent and this desirable change made possible by science. It has various applications in the fields of consumer electronics, information technology and entertainment field. Motion is taken as important factor in video sequence applications and this motion happens because of camera movements and moving things in 3-D scenes. Motion which can easily be visible to human eyes is called optical flow and this captures the movements in the scene through the pixel changes. Various motion estimation techniques are used for motion detection and they are based on improvement of image contents. For any computer vision and video sequence main factors are correct and efficient motion detection [1].

There are various fields in which digital image processing is employed. It has a great impact of digital image processing on each and every area of technology. It became a popular area that each industry wants to accept it very easily or we can say it become a necessary part of the industries. This processing is used according to sources available. These sources are visual, X-ray, etc. Electromagnetic Energy Spectrum is the main energy source of images but some other sources are also available i.e. ultrasonic, acoustic, and electronic beam. With the help of computer synthetic images are generated that are used for modelling and visualization [2].

Image processing methods began in the late 1960s and early 1970s to be used in medical imaging, remote earth possessions observations, and astrophysics. Digital video coding has regularly increased in importance since 90s when MPEG-1 first emerged. It has had large influence on video delivery, storage and presentation. Compared to analog video, video coding achieves higher data compression rates without significant loss of subjective picture quality.

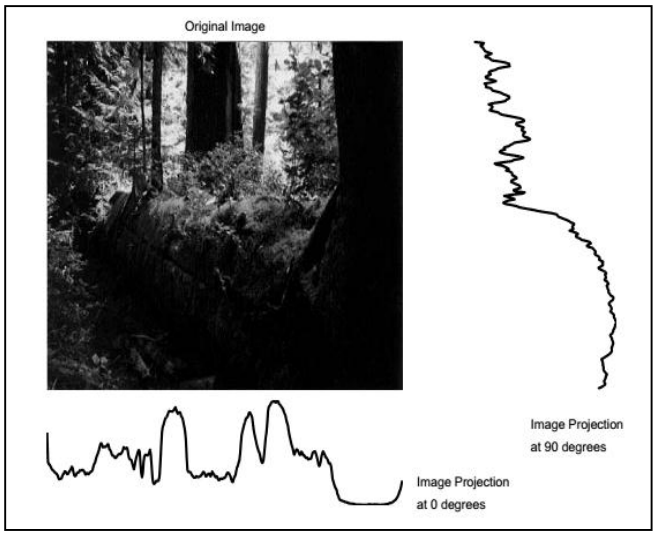

Figure 1: Set of Projections of Forest Image [1]

This eliminates the need of high bandwidth as required in analog video delivery. Hybrid video coding architectures have been employed since the first generation of video coding

standards, i.e. MPEG. MPEG-1 is a video compression standard developed in joint operation by International Standard Organisation (ISO) and International Electro-Technical Commission (IEC). MPEG can be used at higher bit rates than H.261, at about 1.5 megabits per second, which is suitable for storing compressed video stream on compact disks or for using with interactive multimedia systems [3].

Motion estimation and compensation are used to reduce temporal redundancy between successive frames in the time domain. Transform coding, also commonly used in image compression, is working to reduce spatial dependency within a frame in the spatial domain. Entropy coding is used to reduce statistical redundancy over the residue and compression data. This is a lossless compression technique commonly used in file compression [4].

Changes between frames are mainly due to the movement of objects. Using a model of the motion of objects between frames, the encoder estimates the motion that occurred between the reference frame and current frame. This process is called motion estimation (ME). The encoder then uses this motion model and information to move the contents of the reference frame to provide a better prediction of the current frame. This process is known as motion compensation (MC), and the prediction so produced is called motion compensated prediction (MCP) [4].

The paper is organized as follows. In section II, we discuss frame prediction approaches. In Section III, It describes proposed work of frame prediction. In Section IV, it describes the proposed results related to system. Finally, conclusion is given in Section V.

2. FRAME PREDICTION APPROACHES

Motion estimation generally taken as backward motion estimation, since the current frame is considered as the candidate frame and the reference frame on which the motion vectors are searched is a past frame, that is, the search is backward and backward motion estimation leads to forward motion prediction. But forward Motion Estimation is just the opposite of backward motion estimation as the name indicates, here, the search for motion vectors is accepted out on a frame that appears later than the candidates frame in sequential ordering. In other words, the search is “forward”. Forward motion estimation leads to backward motion prediction. It may show that forward motion estimation is abnormal, since one requires future frames to calculate the candidate frame. There are two basic approaches to motion estimation.

- Pixel based motion estimation
- Block-based motion estimation

The pixel based motion estimation approach seeks to determine motion vectors for every pixel in the image. This is also referred to as the optical flow method, which works on the fundamental assumption of brightness constancy that is the intensity of a pixel remains constant, when it is displaced. In block based motion estimation, the candidate frame is divided in to non-overlapping blocks and for each such candidate block, the best motion vector is determined in the reference frame. Here a single motion vector is computed for the entire block, whereby we make an inherent assumption that the entire block undergoes translational motion. From the last 2 decades various fast algorithms are proposed to pursue low computational complexity, some of them are TSS, NTSS, FSS, DS, Hexagonal Search algorithm etc.

The motion estimation module creates a model by modifying one or more reference frames to match the current frame as closely as possible (according to a matching criterion). The current frame is motion compensated by subtracting the model from the frame to produce a motion-compensated residual frame. This is coded and transmitted, along with the information required for the decoder to recreate the model (typically a set of motion vectors). At the same time, the encoded residual is decoded and added to the model to reconstruct a decoded copy of the current Frame (which may not be identical to the original frame because of coding losses). This reconstructed frame is stored to be used as a reference frame for further predictions.

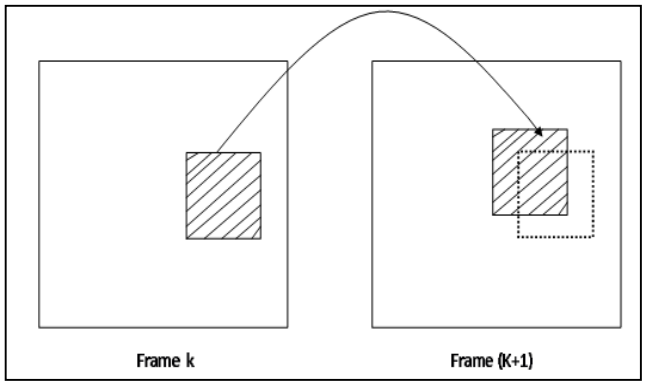

Figure 2: Forward Motion Prediction [2]

To eliminate the large amount of temporal and spatial redundancy inter frame predictive coding is used that exists in video sequences and helps in compressing them also. In conventional predictive coding the modification between the present frame and the projected frame is coded and conveyed. If prediction will be better, then the error will be smaller and hence the transmission bit rate when there is motion in a sequence, then a pel on the same part of the moving object has a better prediction for the current pel.

Block size is the important parameter of the motion prediction. It should be smaller because if the block size is smaller, it achieves better prediction quality and it has a number of

reasons. A smaller block size can minimizes the effect of the accuracy problem and in other words, a smaller block size, provides less possibility that the block will contain different objects moving in different directions. It also has advantage that a smaller block size provides a better piecewise translational approximation to non-translational motion.

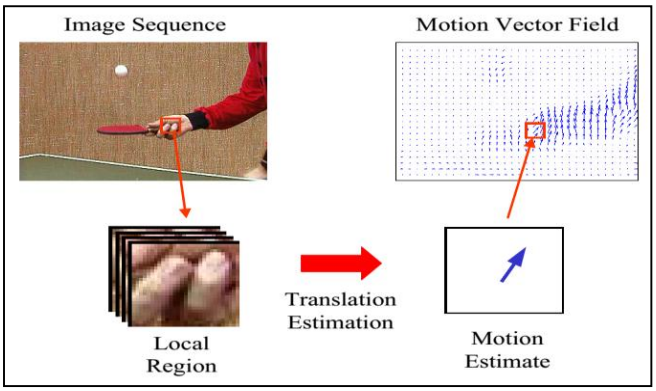

Figure 3: Local Translational Estimation [2]

Pixel based motion estimation approach determines the motion vectors for every pixel in the image. This method also referred to as the optical flow method that works on the basic statement of brightness and reliability that is the intensity of a pixel remains fix, when it is displaced from its position. However, no distinctive match for a pixel in the reference frame is found in the direction normal to the intensity gradient. It is for this reason that an additional constraint is also introduced in terms of the smoothness of velocity (or displacement) vectors in the neighborhood. This algorithm has smoothness which makes the algorithm interactive and requires extremely large computation time, making it inappropriate for practical and real time implementation and applications.

3. PROPOSED FRAME PREDICTION & RECONSTRUCTION

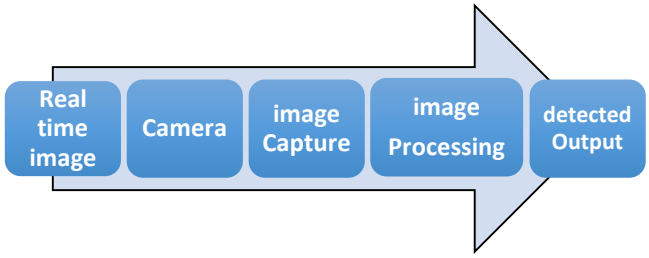

Figure 4: General Steps of Proposed System

The main problem is to detect and reconstruct the motion in real time with less computation time. The block based approaches only reconstruct the image with the cost of high computation time. To solve this, it proposes an algorithm to detect and reconstruct real time motion using pattern similarity technique. In this, it uses pixel concept for motion detection and block based concept for motion reconstruction. It also decreases computation time as compared to block based approaches.

We know that motion estimation is a process that calculates difference of two frames. It may be consecutive in nature. They used statistical information that featured activities of motion in previous frame. It helped in predicting the characteristics of current frame. They can skip checking points and make a decision on early termination. They presented an application to increase speed of motion detection with minimum loss of code efficiency. In video coding, the motion estimation is used to compress video sequences. The motion estimation is done either by pixel approach or block based approach. In block based, various techniques are used like TSS, 4SS etc. So, many algorithms are developed to address the problem of motion estimation in real time.

In block based technique, original image is partition into different blocks and the same dislocation vector is assign to all pixels within a block. The motion system assumes that an image is composed of inflexible objects in translational motion. Though the hypothesis of translational motion is considered to be a major disadvantage in the presence of zoom but the block matching technique is able to guess closely the true motion.

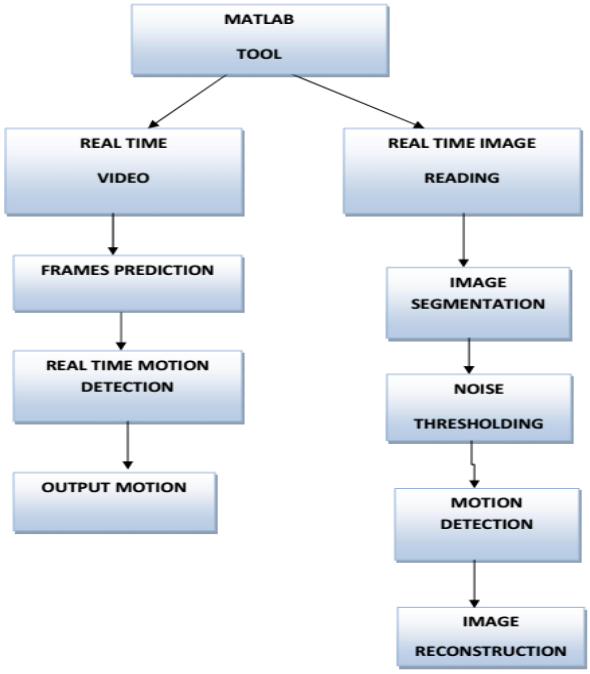

Figure 5: Proposed Steps of System

Motion estimation is used to de-correlate the temporal reliance of the input video series. A motion inference unit at the video

encoder in general includes the following steps. In the first step, motion inference is used to guesstimate the motion between blocks in the reference frames and a block in the current frame. The second step creates the displaced motion remunerated frame and is referred to as motion compensation. The final step obtains the remaining frame as the difference between the current frame and the displaced motion compensated frame. A similar procedure is performed at the decoder. The decoder first decodes the residual frame. Then it obtains the motion compensated frame using the motion vectors and the reference frames. Finally the difference frame is added to the motion compensated frame to obtain the reconstructed current frame. This reconstructed frame can be used as the reference frame for the next frames. The residual frame obtained in the motion estimation step is then sent to a transform coder to de-correlate the spatial redundancy.

Motion inference creates a model of the current frame based on accessible data in one or more previously encoded frames called reference frames. These reference frames may be 'past' frames or 'future' frames (i.e. temporal order). The design goal for a motion estimation procedure is to model the current frame as precisely as possible. The encoder forms a model of the current frame based on the samples of a previously transmitted frame. The encoder attempts to 'compensate' for motion in a video sequence by moving or warping the samples of the previously transmitted 'reference' frame. The resulting motion-compensated predicted frame (the model of the current frame) is subtracted from the current frame to produce a residual frame. At the same time, the encoded residual is decoded and added to the model to reconstruct a decoded copy of the current Frame (which may not be identical to the original frame because of coding losses). This reconstructed frame is stored to be used as a reference frame for further predictions.

Algorithm:

1. Set the camera settings manually.
2. Start the camera using MATLAB tool.
3. Search the entire area and then calculate difference of two images.
4. Comparing pixels row and column vise.
5. If there is difference in pixel value, then it takes the difference of images and hence motion is detected else image is same. Or no motion is occurred.
6. Then image is reconstructed using motion vectors.
7. Calculate performance parameters like MSE, PSNR and computation time.
8. Reconstruct the frame by using block based concept.
9. Compare the proposed performance with TSS and 4SS algorithm.

4. SIMULATION RESULTS

The initial step for this is to interface MATLAB with Webcam (either external or internal). After interfacing, adjust the settings manually. In this, it requires interfacing of camera with Matlab. We know that a video image is a projection of a 3-D scene onto a 2-D plane. A still image is a 'snapshot' of the 2D representation at a particular instant in time whereas a video sequence represents frames moving over a period of time. After reading the image, it converts into grayscale or a binary image. The output image replaces all pixel value in the input image with luminance greater than level with the value 1 (white) and replaces all other pixels with the value 0 (black). After this, segmentation process if followed. The objective of segmentation is to categorize each RGB pixel value in a given image as having a color in the specified range or not.

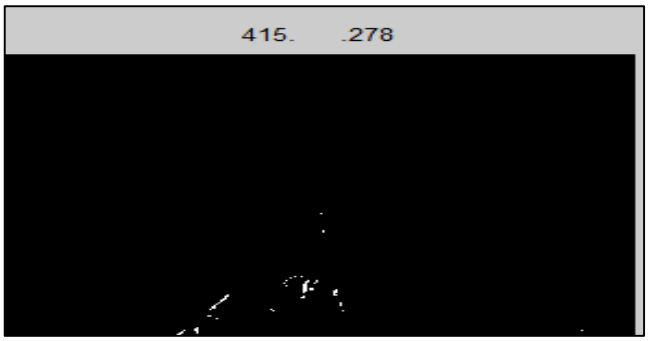

Figure 6: Real Time Motion Prediction

After reading, it converts the original image to a binary image by using im2bw (image to black & white) function. In this, it converts the image into 1 & 0 pizel value. In process of Segmentation, it separates image into its components. In this, it is used to separate R, G, B color from colored image so that operations are applied on single color.

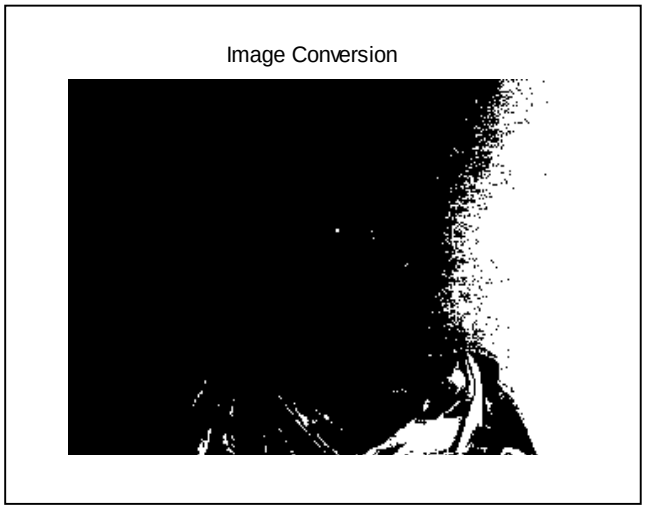

Figure 7: Image Conversion Output

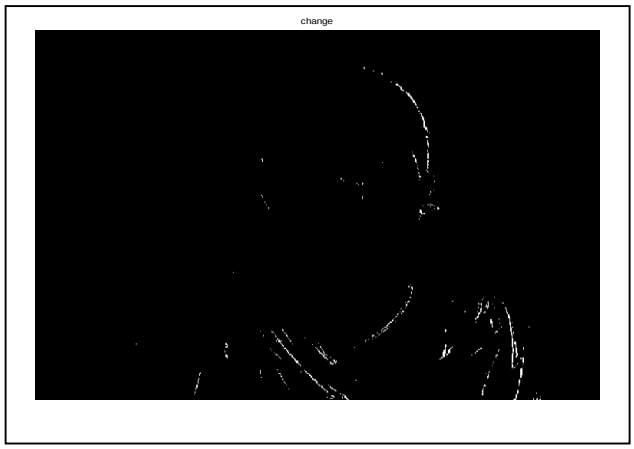

Figure 8: Real Time Motion Prediction Output

It detects the motion between two consecutive frames by matching the current frame as closely ao possible (according to a matching criterion). In this, two frames of images are taken and apply some operations on it. The current frame is motion compensated by subtracting the model from the frame to produce a motion compensated residual frame. After that, find the objects of difference image and then check whether there is some difference occur. The decoder algorithm reconstructs the block as follows:

- In this, fristly decode the difference block and then use motion vector.
- Add the diffrence block factor to the matching region in the reference frame.

The peak signal to ratio (PSNR) and MSE is an important parameter in image processing. Mean squared error provides a measure of the energy remaining in the difference block. Varying block sizes, or irregular- shaped regions, can be more efficient at matching true motion than fixed 16 x 16 blocks. In predictive three step search, for finding the best matching area in reference frame, it is necessary to carry out comparison of current block with best matching area in reference frame. In this, a good match for current block can be easily found in neighbourhood of block position in reference frame. Hence in practical implementations, the search for a matching region is limited to a 'search window', typically centred on the current block position. In three step search, the search window is 2^N-1 where N is step search factor. The output images contain input frame images, segmented output and then reconstructed output image using motion vectors.

The comparison of proposed pixel approach and Three Step Search is shown in Table 1. This table compares this by performance parameters PSNR and computation time. From this, it shows that proposed approach has high PSNR value and low computation time as compared to block processing technique.

Delay=0.1 sec			
Parameters	**Proposed Approach**	**PTSS**	**FSS**
PSNR	29.73	24.8	-23
RMSE	69	216.15	211.5
Computation Time	64 sec	68 sec	82 sec
Delay=0.2 Sec			
PSNR	26.76	25.74	-21
RMSE	78.45	174.65	202.3
Computation Time	67.9 sec	68.19 sec	78.96 sec
Delay=1 Sec			
PSNR	21.87	21.02	-27
RMSE	86.09	164.6	541.05
Computation Time	62 sec	69 sec	72.78 sec
Delay=2 Sec			
PSNR	20.8	26.8	-32
RMSE	88.56	165.4	434.6
Computation Time	66 sec	82 sec	87 sec

Table 1: Parameters Analysis of System

5. CONCLUSION

This work proposes frame prediction and reconstruction using pixel motion estimation technique along with block based technique. Because of using block based approach a factor named computation time get reduced. This work also proposes motion estimation with enhancement so that it adjusts contrast of input frames. It also proposes real time compressed video motion estimation. Motion estimation is used because it forms a main computation block in video applications, for example detection of noise in image sequences, prediction of lost data in image sequences and de-interlacing of image also. The algorithm which is proposed in this work can minimize the computational time as compare with block based approach. The techniques which can reduce temporal redundancy between adjacent frames very effectively and are widely applied to video coding standards are motion estimation and compression techniques. Results have shown that the proposed algorithm can reduce the computation time for pixel approach. The PSNR values of proposed method are also better than actual one.

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