

Chapter 7

Conclusions and Future Directions

In this thesis, we have developed new algorithms for solving image restoration and zooming problems. The proposed methods are validated for (a) color image restoration (b) Still image zooming and (c) Video zooming. Models were formulated based on the need for computational efficiency. Requirements included (a) Degradations across the channels, instead of degradations which are independent of the color channels (b) a faster zooming method, which can retain sharp edges in the images, and (c) a scheme to zoom video in the compressed domain, independent of compression methodology. Moreover, it is important that the models generated are general in nature, and can be applied to different classes of images. The proposed models satisfy these requirements.

7.1 Specific Contribution

Three major contributions of this thesis are in the areas of color image restoration, still image zooming and video zooming.

1. *Color Image Restoration:* We have proposed a new interchannel interaction model, which takes interchannel degradations into consideration. We assume blurring within channel is known, and, blurring across the channel is unknown. That is blur is partially known, making the proposed model partially blind. Proposed model is also robust, in the sense that performance does not change appreciably even when the blurring across the channel varies. The model is capable of restoring the image effectively. Image output is better compared to the model that does not consider inter-channel interaction, both visually and numerically (SNR-wise). Main limitation is the speed of computation. Use of simulated annealing makes algorithm

converge to global minima slowly, thereby increasing computation time.

2. *Still Image Zooming:* We have proposed a new approach for image zooming using wavelets. The proposed approach employs the idea of estimating wavelet coefficients at a finer resolution, using data that is available at a coarse resolution. Coefficients at finer resolution are estimated as a ratio from coarser resolutions, thereby making the algorithm fast. Algorithm retains sharp edges better than conventional methods (like spline and sinc). It too has its limitations: presence of spurious edges for a specific class of images, which has been mentioned in the thesis. Comparisons with other schemes shows that on the whole, the proposed method performs very well both visually and numerically.
3. *Video Zooming:* We have addressed zooming of the compressed video problem. Novelty of the proposed method is that the zooming is carried out in compressed domain, by interpolating motion vectors. The motion vector interpolation technique gives the flexibility to apply our proposed method to different compression methods. We have justified this fact by considering DCT and DWT based compression methods. Though the results for both the methods are good, we observe that the DWT based method performs better than the DCT based method. Our algorithm is also tested for a video stream, compressed by MRME method. During decompression, we apply our method to interpolate motion vectors and, obtain a zoomed video.

We extend the technique to temporal interpolation (estimate missing frames) of a video stream, in the DWT domain. In this case, motion vectors are used to estimate the position of a block in the missing frame. Performance in this case is comparable to the case when we first decompress the video, and then do a linear interpolation of pixels in adjacent frames.

7.2 Future Directions

In this thesis, we have suggested some new schemes for image restoration, zooming and manipulations of motion vectors to manipulate a compressed video stream. However, there is a lot of scope for *generalizing* the proposed algorithms. We mention some of them here. This, by no means, is complete, and we strongly believe the problems tackled are still open and there is a lot of scope for improvements.

- The restoration model takes first-order neighborhood for across-channel distortion.

One may extend it to a higher order model. Instead of selecting ξ a constant, one may select ξ_{rg} , ξ_{rb} , ξ_{gr} etc., for interchannel distortion between red-green, red-blue, green-red respectively. We have considered linear and space-invariant blur; this can be generalized to a non-linear and space-invariant blur.

- We have assumed a partially known blur. The work may be extended to an unknown blur; thereby we can have a fully blind image restoration. That is blurring operation within the color plane is also unknown and/or the blurring matrix itself may be corrupted by noise.
- An important extension of the proposed zooming methods is to provide a mathematical justification. This may also provide an insight in to the pros and cons of the proposed methods.
- We have shown that motion vector interpolation works for the DCT. This can be extended to an MPEG coded bit-stream. This involves modifying the MPEG decoder part to incorporate interpolation of motion vectors.
- For video zooming, we can down-sample the video in the DCT domain by the method proposed by Dugad and Ahuja [27, 28]. This in turn will lead to a *transcoder* kind of application. That is we can transmit high bit-rate data (video) over a low bit rate channel, and reconstruct the high resolution signal at the receiver. The proposed motion vector interpolation method should be able to handle this requirement easily.
- While estimating missing frames using motion vectors (Section 6.6), we have considered only the I frame. The proposed algorithm can be extended to include P frames also.
- For zooming applications, we have used the Daubechies wavelets. Haar wavelet gives blocky images and higher order DAUB wavelets smoothen the edges. There is a scope for generation of a new set of wavelet bases, which can enhance the performance of the proposed zooming methodologies.

7.3 Postscript

The Chenna Keshava temple at Belur^{1,2}, (Karnataka, India) is an art gallery by itself. The entire temple is full of stone carvings. It has one pillar, which has template of all the idols carved in the temple. However, there is a small space left blank (un-carved) in this pillar. Experts are of the opinion that the blank space signifies:

There is no end to any work

¹<http://www.kamat.com/kalranga/deccan/hoysala/belur.htm>

²<http://www.geocities.com/SoHo/Studios/8487/belur.html>