Chapter 7

Conclusion and Further Enhancements

7.1 Conclusion

Various methods and algorithms have been investigated for affine or RST transformation invariant image registration. Existing algorithms are improved by using appropriate optimization algorithms which gives transformation parameters for best matching in case of area based methods. In existing correlation based algorithms, windows are created for original and sensed images and for each transformation correlation is calculated between correspondence windows of both images and compared but in our modified algorithm whole image is taken as an area, transformation is applied and optimized using Nelder-Mead simplex method so here it requires less computational cost. In mutual information based existing algorithm, original and sensed images are divided in n parts and mutual information is found for correspondence parts but in our modified algorithm we have found joint entropy using joint histogram (includes pixels of both images), normally joint histogram term is used for color image processing for RGB plane but here term is used to describe joint entropy. To find mutual information whole image is used as an area and transformation parameters are applied on sensed images using NM simplex method. These parameters are optimized for maximum mutual information. In our area based algorithms for any translation or scaling images are registered by taking minimum period but if the rotation is more, then NM simplex method requires more iteration so it takes much time. But in our proposed algorithms, for optimization initial scale is very important. If these algorithms are used in particular application where range of rotation is known, then by provided appropriate initial scale in NM method, time for registration can be reduced.

For multi focus and multi modal images, existing registration method uses averaging. In our proposed algorithm we have used principal component analysis. Normally PCA based methods are used in face recognition, compression and machine vision application. In our algorithm we have proposed methods using Principal Component Analysis. Here we have taken those eigen vectors associated with largest eigen values which represent more variance and using PCA re-
sults are improved in all quality measures. When the Principal component is found without windowing (w=1), then it may possible that principle component is found from the same region of the image that is disadvantage of it, this drawback is taken care in our proposed algorithm. We have applied windowed PCA in which individual windows are registered by finding individual principle component for each window and then all windows are aggregated to get registered image. These algorithms are compared using different quality measures.

In multiview image registration, where different images can have different information with some overlapping part, conventional approach uses euclidean warp or affine warp. Matching points are selected manually for finding correspondence in terms of transformation parameters (RST parameter). Limitation of existing method is, if there is some pixel difference in matching points then seems can be visible in registered image, that is shown in our results. In this conventional algorithm, we have applied backward mapping image blending so results are improved. In second proposed algorithm for multi view analysis, after finding transformation matrix for correspondence we have applied Levenberg-Marquardt optimization algorithm in which transformation matrix using affine parameters is optimized to see the minimum error by using all nearest neighbour pixel, so here though minor changes are there in selection of reference points will be neglected, which is also shown in our results. For more than three images, in first approach seems are visible but using LM optimization for transformation matrix it gives 100% results in terms of all information of all images to be registered. So this method can be applied when we want to register images from video sequences. Here as described earlier limitation is in terms of manual selection points.

In automatic multi view image registration, no manual selection is applied. Here interest points are selected using harris corner detector. In our research to find harris corner response we have not used the function given by harris but we have applied the function given by M.Brown[57] to reduce computational cost. In our modified harris corner detector, we have not taken corners close to image borders and also applied non maxima suppression within [3x3] window as described in chapter 6 so image borders cannot be taken as interest points. To find distinct features we have made patches from interest point and only taken those patches with minimum Euclidean distance so computation load is reduces. So this proposed algorithm is computational effective. In this algorithm, homogeneous coordinates are normalized to a scale of unity so homography
can be estimated at the same scale. We have applied this algorithm on images having scaling, translation and rotation differences, and as result all images are registered correctly.

In summary, the thesis contributes to the study, investigation and development of multi modal, multi focus and multi view image registration algorithms.

### 7.2 Further Enhancements

There are number of useful extensions that can be added to the present research work. The possible additions to the present work are stated below.

- In this research work we have considered Euclidean warp (RST transformation) and Affine warp (RST transformation with shearing) as geometric transformation between the overlapping portions of the images. Affine transformation has six degrees of freedom. So these algorithms can be further improved by taking projective transformation which is having eight degree of freedom. It also considers co linearity and incidence. So same proposed algorithm can be improved when the images to be registered are taken with different distances.

- Proposed area based method, using correlation and mutual information can also be applied for extracted features and the matching can be applied to register images. As a further enhancement these area based methods can be combined with feature based methods.

- In our proposed algorithm, for finding homography estimation RANSAC algorithm can be replaced with adaptive homography estimation, in which adaptive method may be investigated for selecting initial point of interest.

- Real time embedded system for image registration can be designed for all these proposed algorithms.

- Distributed registration remains an open problem that can be approached and Fuzzy based methods can also be applied for image registration of different class.

- Multi resolution and multi spectral registration can be explored.