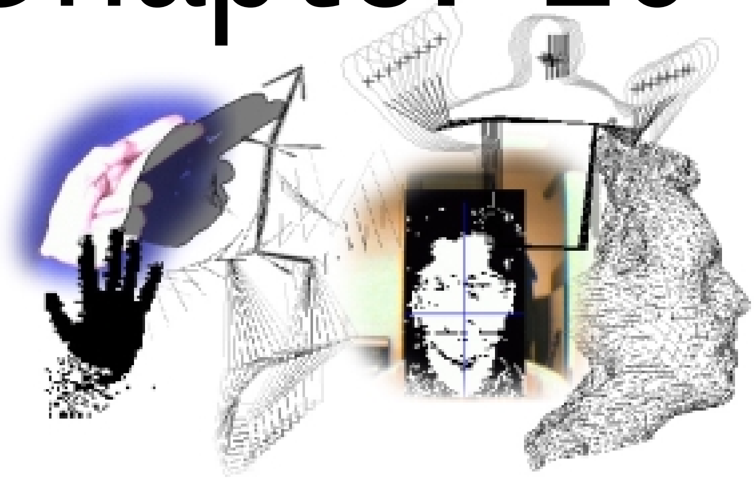
Chapter 10



10 Closing Discussion

10.1 Summary

This thesis has attempted to address the problems associated with the construction and application of deformable contour models for real-time tracking and interpretation of scenes. Deformable models were chosen as a research subject due to their power and speed at segmenting objects under normal environmental conditions where few constraints can be placed upon applications to simplify segmentation. By taking deformable models as a starting point, the work has attempted to push current approaches into new domains where existing techniques would fail. In doing so, a fundamental understanding of the associated problems has been gained and these problems addressed.

After reviewing related literature in Chapter 2, Chapter 3 introduced linear Point Distribution Models and discussed their construction and use in object tracking. It was shown that one of the most important aspects of the PDM is the inherent dimensional reduction of the model.

Chapter 4 discussed the use of colour in object tracking and demonstrated how simple colour techniques could be used to enhance object segmentation. This chapter also demonstrated how object colour could be used in its own right as a powerful feature for tracking.

In Chapter 5 non-linear datasets were introduced and their effects upon linear PDMs discussed. The Cluster Based non-linear PDM (CBNLPDM) was introduced which modelled non-linearity by breaking a dataset down into a piecewise linear approximation to the non-linear data set. It was shown how models could be constructed which better represented non-linearity while retaining the simplicity and speed of the linear PDM. It was also shown that the technique produced superior performance for model representation than other related approaches.

Chapter 6 extended this work and introduced a vital adaptation to the CBNLPDM. By projecting the training set down into a lower dimensional space before non-linear analysis, large computational savings could be made. This approach called Constrained Shape Space PDMs (CSSPDM) allows non-linear analysis to be performed on high dimensional data such as images or 3D structures. It was also shown that the data smoothing effect of this dimensional reduction produces advantages for both model building and reconstructive accuracy. Furthermore the natural segregation of the CSSPDM combined with the low dimensionality provides a mechanism for the static pose recognition of objects. This was demonstrated by using a CSSPDM of the hand to classify letters from the American Sign Language finger spelt alphabet.

In Chapter 7 the important consideration of how objects move with time was introduced. It was shown that this natural segmentation of shape space could be used for discrete time dependent analysis by augmenting the CSSPDM with a markov chain. This was illustrated with 3D motion capture data, where not only the deformation of the model was learnt, but also the motion contained within the training set. Using this motion model plausible mean trajectories of human motion were reproduced which were learnt from recorded motion data and visualised graphically. The temporal CSSPDM was then applied to object tracking and it was demonstrated how it could be used in a simplified CONDENSATION algorithm, which outperformed standard ASM tracking. It was also shown how the PDF used in the Markov chain could be constructed from sources other than the training data, providing superior results. This is especially important in applications such as gesture recognition where it is not feasible to learn this information by example.

In Chapter 8 the extension of Point Distribution Models to the 3D domain was discussed. Techniques for the construction and alignment of such models were presented and results shown for the automatic construction of large 3D eigen models of the human head.

Finally Chapter 9 took many of the techniques and approaches discussed in this work and applied them to the subject of markerless human motion capture. By linking elements together before PCA is performed, a statistical linkage is achieved which allows unseen information to be inferred from available visual queues. This was demonstrated by tracking a human body in a monoscopic image sequence and extracting a corresponding 3D skeletal model which mimicked the motion of the human.

In order to extend the Point Distribution Models to more complex applications it was necessary to address the problems associated with automated model construction. Namely, the complexities that automated procedures introduce to training sets. Unlike many earlier authors who tackled this problem by trying to attempt to devise complex techniques which would minimise these non-linear effects. This work has tackled the problem by attempting to produce models which can cope with these complexities. In doing so, the resulting developed models have become more reliable and accurate while retaining the simplicity and speed of the original formulation. These accurate, fast non-linear models not only produce superior results, but also allow automated models to be constructed which can have any dimensionality or complexity with almost no user intervention.

10.2 Future Work

This thesis has attempted to address the problems associated with the construction of deformable models. In doing so, it has established a set of generic tools and techniques for the construction and application of complex non-linear models of deformation. By addressing the problems of non-linearity, the approaches provide a solution which, has few constraints upon model assembly and hence opens the application base of the work.

Future work is therefore varied and current work is concerned with further developing the construction and application of models with computer vision and graphics.

Current work into the colour distribution of objects and scenes is extending the work of Chapter 4 to provide an accurate method of locating human motion within complex environments. This work will incorporate models of deformation to address the applications of visual surveillance and monitoring.

The work of Chapter 7 is supporting research into two areas, namely computer animation and gesture recognition. In the field of animation the ability to be able to model the motion of complex surfaces in lower dimensional spaces allows smooth key-frame animations to be achieved. It is also intended that these techniques could be combined with the work in Section 9.2 to allow the abstract parameterisation of human motion in simulation. To fully investigate the applications to gesture recognition, a two handed system must be constructed which allows temporal gestures to be both tracked and classified.

A new model of human motion is currently being constructed, extending the work of chapter 9. This model consists of a tri-camera view of the human subject with the corresponding optical motion capture ground truth. This new model will provide the means to assess the accuracy of the inferred human structure and investigate the associated accuracy of mono, stereo and tri camera reconstruction.

It is also intended that the work described in Appendix 2 on volumetric segmentation be combined with that of the construction of 3D PDMs for medical analysis and diagnosis. In doing so the shape and size of internal organs can be compared with a statistical model to gain an indication of variation from the population mean. It is intended to investigate the use of such approaches in the diagnosis of medical conditions such as hydrocephalus.