Supplementary Report of Research Progress

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Aims Revisited

A suitable way of describing any undertaken research is to briefly describe its aims in a simplistic form that requires little understanding of its background. Given a collection of, let us say, images, which are clearly different although they describe the same object, we wish to transform them in some way so that they appear as identical as possible. The solution to this task is not unique, meaning that we have infinitely many solutions, i.e. transformations, that get similar results. We can use an existing technology to model all these images and use this technology to minimise a term of complexity. We contend that when this term is minimised, better similarity across the set of images is granted.

This process is also beneficiary because one if its byproducts is the description of the transformations. Such descriptions can be used, in a process of learning, to form knowledge about the observed differences. They can be used to construct models which are capable of regenerating the images.

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Experiments and Milestones

There were many experiments performed, but this report will focus on a few which inferred important information and conclusions that ought to be highlighted.

The following experiments are the more interesting ones among the entire set of experiments. Each of these may be explicitly or implicitly mentioned later on as minor milestones are dealt with in turn.

1. Registration target and approach of the model-based evaluation to it.
2. Comparison and benchmark of different registration methods.
3. Finding the correlation between the size of the set and the performance of the model-based objective function.
4. Point insertion to compensate for the change in bump height.
5. Use of the residual of the model to better perform (4).
6. The optimisation refusing to improve steadily, fixed by dynamically changing the precision required from the optimiser.
7. Finding out that optimisation can go below target even when initialised at the correct solution described by a piece-wise linear warp.
8. Considerable speed-up of the algorithm.

Registration Target

As well as knowing how transformations behave and how they affect the data, a measure of model quality needed to be established and plotted against steps in the algorithm. To make this value more meaningful, the value that one aspires to reach was estimated and shown in the plot.

Improved Model-based Objective Function

Towards the end April 2004, many solutions where found which substantially improved the objective function and finally made it work. Further options also made it work relatively efficiently and obtain impressive results.

Varying Weights

In May 2004, a further investigation of the ratio between shape and intensity began. As a result, ways of stabilising the objective function at convergence may have been identified.

Hybrid Objective Functions

Much earlier in the year, a combination of objective functions was investigated, mainly that of MSD and model-based.

Comparative Analysis of Objective Functions

In late 2003 and in early 2004, a comparative analysis of different registration methods was conducted. Some results are shown in Figure 2.

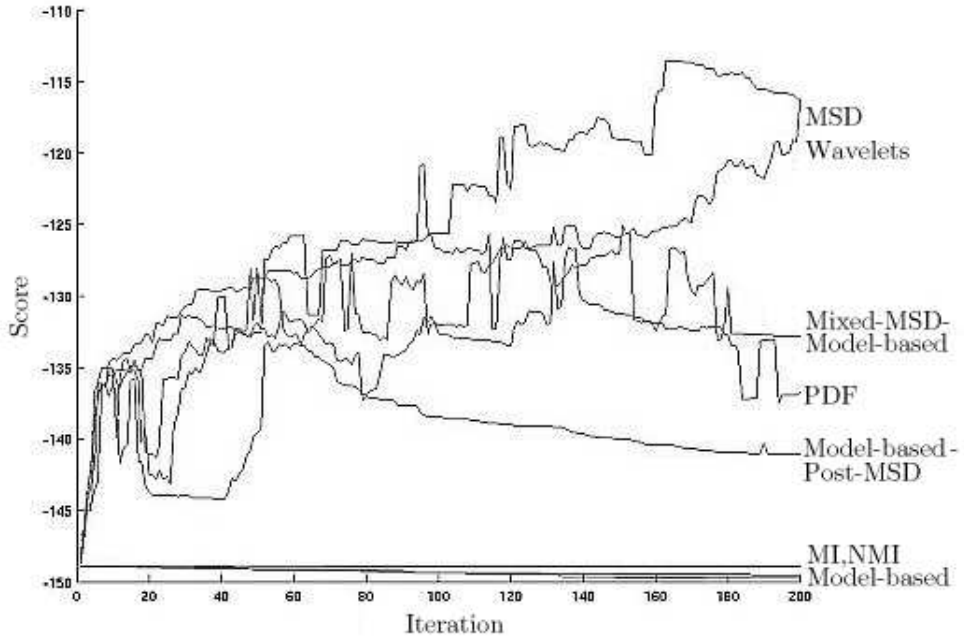

Figure 1: A comparative analysis of objective functions illustrating that the model complexity decreases only for our newly-proposed objective functions. The Y-Axis value is an indicator of model compactness.

Point Insertion

An issue was recently encountered where data drifted away quite slowly; whereupon convergence can never be reached. The issue is worrying as it was found in Davies' work as well. This leads to the next point which is the model residuals. Present work places great emphasis on this matter.

Model Residuals

Of current interest is the way in which model residuals can prevent erosion of data and hence improper models. By resolving such a problem, better registration performance will be yielded.

Analysis of Warps

Throughout the entire year, there was some general interest in how clamped-plate splines affect the data and how the model-based objective function affects the choice of warps. Some of the drawbacks of families of warps and the problems concerned with diffeomorphism were identified, yet these are of greater interest to Marsland and Twining.

Impending Experiments

At the time of writing, work is being put into the extension of automatic landmark selection for shapes. It is now realised that the model residuals need to be included in some form or another (e.g. MDL) in the objective function for images and a good starting point is the simpler case which is shapes[1]. When landmarks can be identified correctly *and* the objective function reaches stable convergence, application of the proven principles to images shall resume. A detailed list of experiments and work to be done on images can be found in various personal memos and in the weekly progress reports (see above).

[1] Most recently it turned out to have been complicated.