



ANNEX A – Master Thesis Proposal

1. Student Information

Family Name: Margeta

First Name: Ján

Passport Number: 4126721

e-mail: jmargeta@gmail.com

Date and Signature

17/02/2009

2. Master Thesis Information (use as many pages as needed)

Title: Investigations in volume registration

Description:

Registration is the process of discovering the spatial transformation which best brings two images or volumes into alignment. There are two broad categories of registration:

Rigid registration constrains the mapping to a small number of global parameters – such as an affine transformation.

Non-rigid registration involves the discovery of a *warp field* defining the mapping from the *reference* volume to the *template* volume.

Registration of medical datasets is becoming increasingly central to many aspects of medical image analysis. For example:

- Fusing datasets acquired for the same patient from different scanner modalities – particularly CT and MR. We call this *inter-modal* registration, which may require both rigid and non-rigid registration.
- Discovering the correspondence between follow-up scans of the same patient, where several months will have elapsed such that pathology may have progressed or regressed, and the patient extent of the scans may be substantially different. Usually only rigid registration is required.
- Registering a novel dataset with an atlas dataset including predefined segmentations. This enables atlas-based segmentation and is a powerful method of segmenting various organs in a range of modalities. This requires *inter-patient* registration. Both rigid and non-rigid registration are required.
- Perfusion studies involve measuring the take up of intra-venous contrast agent by repeated CT or MR acquisitions spread over 1-2 minutes. Due to patient movement, breathing and involuntary organ movement the sequence of scans will not be in perfect alignment making perfusion measurements inaccurate. Non-rigid registration is required



to remove these movement artefacts, leaving the true perfusion signal as the only difference between the phases.

Aims:

The general theme of this project is to take a fresh look at both rigid and non-rigid registration, with one eye on the literature and current state of the art, the other on Toshiba Medical Visualization Systems Europe Ltd's (TMVSE's) existing approaches and implementations. We hope that out of this study will emerge a better understanding of the properties of the current implementation, and some proposals on how it might be improved.

Tasks:

Review key literature on approaches to registration - both rigid and non-rigid, to gain a good understanding of the field.

Review the current TMVSE implementations of registration, to understand how our approach fits into the spectrum of approaches as understood from the literature survey.

Investigate the following both theoretically and empirically:

- **Estimating Mutual Information.** Estimation of MI is sensitive to the method and parameters used to obtain the joint distribution, and these are apparently linked to characteristics of the volume data – such as size, dynamic range, and noise level. Based on the above investigation, propose improvements to our method of computing mutual information. Also investigate possible alternative measures such as *correlation ratio*, and compare their performance against mutual information. It is expected that this work will be limited to rigid (including affine) registration.
- **Thin-plate splines.** The current approach to non-rigid registration represents the evolving warp field as a simple vector field, with fluid and elastic constraints implemented by Gaussian smoothing to the incremental and cumulative warp fields respectively. A more sophisticated approach represents the warp field as a ‘thin-plate spline’, and frames the registration problem as one of optimisation within the space of the spline parameters. Fully understand the thin-plate spline based approach to non-rigid registration and provide a Matlab implementation of the core aspects of this approach.
- Investigate the performance of the thin-plate spline approach, based on the registration of an adequate number of small medical datasets (both intra- and inter-modal), using mutual information as similarity measure, and compare performance with our current implementation.

Planning:

January

- Review of existing nonrigid registration approaches.
- Study new object oriented programming techniques in Matlab 7.7.0.

February

- Evaluate alternatives similarity measures and compare them to mutual information.
- Implement thin-plate splines and compare to other to other existing non-rigid deformation methods.
- Use thin-plate splines (or more suitable alternative) for 2D nonrigid registration.
- Investigate automatic landmark placement methods.
- Study non-linear stochastic optimization techniques.
- Commence writing *Introduction* and *Literature Review* chapters.

March

- Develop and implement an automatic 3D nonrigid registration.
- Comparison of the proposed solution with other approaches.
- Commence writing *Comparison of similarity measures* chapters.

April

- Refactor the solution.
- Analyse and summarize obtained results.
- Commence writing *Thin plate spline*, *Results* and *Discussion* chapters.

May

- Finalize experiments.
- Finalize writing of the thesis

3. Supervisor Information

Name: Jim Piper

Department: Image Analysis

Institution: Toshiba Medical Visualization Systems

e-mail: JPiper@tmvse.com

Date and Signature

18/2/09

