IMAGE REGISTRATION BY MODEL CRITERIA

AUTHORS

ABSTRACT. The need to establish correspondence across groups of images has for long been recognised. The problem is invariantly referred to as registration. To enable comparative analysis of images depicting similar a similar object, analogous object structures must be identified and a practical way of doing so is by aligning these structures. The alignment is achieved by treating each image as a deformable entity and transforming it to match another. One image is said to match another when it appears similar, i.e. objects within it overlap. The framework describing a registration scheme is specified by an objective function which comprises both transformations and similarity measures. The former describe the means by which images are changed and the latter are ways of assigning score to that change.

There is no agreement in the literature on what is considered a powerful family of transformations; A good choice of transformations also depends on the problem under consideration. It is also unclear what correctly defines similarity and which images should be compared when measuring that similarity. Popular methods are based on heuristics and results are difficult to validate. Our work addresses these issues not by finding good registration schemes empirically, but by providing a well-founded approach to the problem. Since registration is known to reduce variation within groups of images, a model which represents these images will be accordingly affected. By looking at a model, we obtain a view atop the entire problem, without needing to delve into the level of individual images. Moreover, when models are used in the process of registration, their high level of functionality becomes available and statistical models are created.

The objective function presented in this work obtains similarity indirectly. It does so by calculating the complexity of a statistical model, namely by looking at the covariance matrix of that model. It makes the registration purely model-driven so that no choice of images is needed for comparison. The objective function leads to one distinct solution without dependence upon individual images. This resolves the recurring issue of having to select a template image and treat the problem as if it relies primarily on that one image. To transform images, we use the clamped-plate splines which address known flaws often encountered when thin-plate splines and the B-splines are used. The clamped-plate splines prevent any of the regions in an images from being torn or folded, hence they preserve the existence and integrity of all

image regions. Particularly in the bio-medical domain, visibility of all constituent structures becomes crucial.

To demonstrate the advantages gained by the model-based approach, we experimented with one dimensional synthetic data where the correct solution is known. Generated data depicted a bump, essentially an half-ellipse, which varied in its height, width and position. The sets were stochastically generated with significant difference in values. We describe a solution to be good when we observe proper alignment of the bumps and a resulting registered set that is distinct from any of the original images. At the same time, we are continuously delivered statistical models of variable bumps and well-founded ways exist to visualise and evaluate models.

After only several minutes, good alignment amongst all bumps was obtained. Sets comprising dozens of bumps could be successfully handled by the algorithm and statistical model of their appearance emerged as a by-product of registration. Judging by the known correct solution, the quality of registration was high. It also successfully surpassed naïve implementations of some conventional algorithms.

The results we have seen thus far suggest that our approach works properly while addressing common difficulties. It can handle large sets and provide a solution that does not depend on any arbitrary selection of images. Future work will apply this approach in a real-world problem by treating 2-D images of the human brain. In the problem of inter-subject brain registration, where variability is much greater, the damaging effects of choosing individual images crop up. The great benefits of driving registration by models should then become even more apparent and models be generated without the need for any manual mark-up.