Questions and Answers

Chapter 9

Questions

(Q1) *What is image registration?*

(Q2) *What is a correspondence function?*

(Q3) *What is image warping?*

(Q4) *What are the usual assumptions in motion analysis?*

(Q5) *How would you use an atlas for segmentation?*

(Q6) *Which four attributes do the authors use to classify registration algorithms?*

(Q7) *What is the purpose of interpolation?*

(Q8) *What is the relation between variational methods minimizing a scalar criterion and methods described using PDEs? [For further study.]*

(Q9) *Why should a warping model be adapted to the image?*

(Q10) *What is the purpose of regularization in image registration?*

(Q11) *What is the essence of multiresolution?*

(Q12) *Explain the notion of consistency in the image registration context.*

(Q13) *Try classify a typical landmark registration algorithm according to the framework described in the first part of this chapter.*

(Q14) *Why does the Laplacian variational criterion not penalize affine deformation?*

(Q15) *Why are radial basis functions called radial?*

(Q16) *What is landmark interpolation?*

(Q17) *Explain the notion of separability for B-spline basis functions and its impact on speed.*

(Q18) *What is the consequence of setting the virtual spring weights* α *too high or too low?*

(Q19) *How does the registration result depend on the chosen optimization algorithm?*

(Q20) *What is the relation between the reduction and expansion operators* $\mathcal{R}$ and $\mathcal{E}$?

(Q21) *Does the positivity of the Jacobian guarantee the global invertibility of the deformation?*

Answers

(A1) Image registration is the task of finding corresponding points in two images.

(A2) It is a function that maps coordinates from the reference to the test image.

(A3) Image warping is the process of geometrically deforming an image according to a deformation function.

(A4) In motion analysis we normally assume that all changes between frames can be explained by movements of the scene or of the camera, that the changes are relatively small and movement smooth.

(A5) A new unlabeled image can be registered with the labeled reference image and then the labels transfered back to the new image.

(A6) The algorithms are classified according to the feature space, search space, cost function and search strategy.

(A7) Given function values at discrete points (knots), interpolation provides a continuously-defined version of the same function, coinciding with the prescribed values at knots and making a qualified guess between them.

(A8) Given a variational scalar criterion on a deformation field, it is usually easy to find a PDE describing a time evolution of the deformation field converging to the desired solution. Sometimes it might be possible to find a spatial PDE on the deformation field (not involving the time component) describing the desired result through Euler-Langrange relationships. Conversely, the transition from a spatial PDE to a variational criterion is easy; for PDE's describing time evolutions, this is only possible in special cases.

(A9) Refined and flexible warping model is needed in image regions containing enough information permitting to determine the deformation with high accuracy. In flat, or homogeneous regions, there is no point in using a complicated deformation model; on the contrary, it can even decrease the stability of the algorithm. This way, we can distribute the computational effort exactly as needed.

(A10) Regularization supplies a priori knowledge about the deformation, to guide the algorithm in zones without enough information in the images; it stabilizes the registration process.

(A11) Multiresolution approaches start to solve a simplified, coarse-scale version of the problem. The solution is then used as a starting point for progressively finer versions of the problem until the original scale is reached.

(A12) Consistent registration algorithms provide both forward and backward mappings between the two input images, guaranteeing that their composition (going from one image to the other and back) is close to identity.

(A13) Landmark registration is a feature-based method, working with a parametric deformation models and finding the solution directly based on inter-image landmark distance. (Other variants of landmark registration are also possible)

(A14) Because the affine deformation is linear in all coordinates and its second derivatives are therefore zero.

(A15) Because while they are the functions of a position $\mathbf{x}$, they only depend on the radius $r = \|\mathbf{x}\|$.

(A16) Landmark interpolation is the task of determining the correspondence function between landmark locations.

(A17) B-spline basis functions in multidimensional space are formed as tensor products of 1-D B-splines. Therefore, for example, instead of having to evaluate the 2-D B-spline at $n \times m$ points, it is enough to evaluate only the 1-D B-spline at $n + m$ points and form the tensor product of the results.

(A18) A weight α that is too small might not succeed in making the algorithm to converge to the right solution, while α too high will force the solution to a landmark position that is perhaps not sufficiently precise.

(A19) If we let the optimization converge, then the results will be equivalent, regardless of the optimizer used. However, the results might differ in areas not taken into account by the criterion. The main difference between optimizers will be the speed of convergence and possibly robustness.

(A20) In order to minimize errors associated with the scale changes, expansion followed by reduction should not change the original signal. Additionally, reduction followed by expansion should yield a good approximation of the original signal.

(A21) No, only local invertibility. For a deformation to be globally invertible, we need some additional condition, for example that the transformed image boundary does not intersect.