AI in Medicine I
WiSe 2022/23

Technical University Munich
Department of Informatics

I31 - AI in Medicine and Healthcare
I32 - Computational Imaging in AI and Medicine

Theoretical exercise 2 **10. Nov. 2022**

Image Registration

The solutions will be discussed in the tutorial session

10. Nov 2022, 4-6 p.m. in lecture hall 5901.EG.051

For questions regarding this exercise sheet, please contact: `vasiliki.sideri-lampretsa@tum.de` & `veronika.zimmer@tum.de`
For general questions, please contact: `course.aim-lab@med.tum.de`

1 Multiple choice questions

1. (1 point) What is the aim of medical image registration?
   (a) Analyse an image and identify the class in which the image belongs.
   (b) Divide an image into subgroups (segments).
   (c) Establish spatial correspondences between two or multiple images.
   (d) Storing knowledge gained while solving one problem and applying it to a different one.

2. (1 point) Which of the following is part of an image registration algorithm. (More than one correct answer.)
   (a) Cross-entropy loss.
   (b) Spatial transformation model.
   (c) Interpolation method.
   (d) Optimisation method.

3. (1 point) What is the role of interpolation in medical image registration?
   (a) Up-sample images.
   (b) Down-sample images.
   (c) Minimise cost function.
   (d) Estimate data values at unknown spatial locations.

4. (1 point) Do we need regularisation in image registration to restrict the search space for optimisation?
   (a) Yes, when we are performing rigid registration.
   (b) Yes, when we are performing affine registration.

(c) Yes, when we are performing deformable registration.

(d) In all the above cases.

5. (1 point) Multiple choice question

   (a) (0.5 points) MSE (Mean Square Error) can be used as a similarity metric in multi-modal registration.
   A. True B. False

   (b) (0.5 points) One advantage of conventional registration is that it can register the images faster than a learning-based registration.
   A. True B. False

   (c) (0.5 points) Segmentation label overlap can be used to evaluate image registration.
   A. True B. False

   (d) (0.5 points) A deformable transformation has 6 degrees of freedom.
   A. True B. False

   (e) (0.5 points) A multi-resolution approach in image registration helps capturing larger deformations.
   A. True B. False

2 Open questions

1. (5 points) Conventional vs learning based registration.

   (a) (1.5 points) Make a sketch of a conventional pairwise image registration algorithm.

   (b) (1.5 points) Make a sketch of a deep learning image registration algorithm.

   (c) (2 points) Name aspects in which the algorithms differ and aspects that they have in common.

2. (5 points) Similarity metric.

   (a) (3 points) Please write the generic formula of a cost/loss function used for deformable image registration. Explain briefly which symbols you have used.

   (b) (2 points) Name 2 mono-modal and 2 multi-modal image similarity metrics using their full name and not only the abbreviations.

3 Coordinate system transformation

1. (5 points) Given a point $\mathbf{p} = \begin{pmatrix} -1 \\ 3 \end{pmatrix} \epsilon\ \mathbb{R}^2$

   (a) (2.5 points) Calculate its rigid transformation using image coordinates, i.e. centre of rotation $\begin{pmatrix} 0 \\ 0 \end{pmatrix} \epsilon\ \mathbb{R}^2$ and scaling $= \begin{pmatrix} 1 \\ 1 \end{pmatrix} \epsilon\ \mathbb{R}^2$, when: $\phi = 30°$ and $\mathbf{t} = \begin{pmatrix} 2 \\ -1 \end{pmatrix} \epsilon\ \mathbb{R}^2$.
   Hint: Please consider using homogeneous coordinates.

   (b) (2.5 points) Calculate its rigid transformation $\phi = 30°$ and $\mathbf{t} = \begin{pmatrix} 2 \\ -1 \end{pmatrix} \epsilon\ \mathbb{R}^2$ using word coordinates, where the world origin is $\begin{pmatrix} 10 \\ -5 \end{pmatrix} \epsilon\ \mathbb{R}^2$, the scaling is $\begin{pmatrix} 2 \\ 2 \end{pmatrix} \epsilon\ \mathbb{R}^2$ and the world coordinate system is rotated 45° compared to the image one.