Laboratory X. Segmentation of organs from magnetic resonance tomography images

1 Introduction

A biomedical engineer should possess a basic anatomical and physiological knowledge. Such knowledge is helpful in realization of the majority of biomedical engineering tasks. For example, in the biomaterials science a good knowledge of tissue or bone types and characteristics is useful. In biomechanical engineering, the mechanical properties of joints and tissues are important.

For engineers designing algorithms for medical practice, it is essential to know the anatomy and physiology of particular body areas. During this laboratory, the latter aspect will be practiced.

Image segmentation is one of the basic issues in the field of image processing. Accurate segmentation of body structures makes it possible to investigate different organs, visualize them or diagnose diseases. The techniques used in image processing at the Lodz University of Technology are introduced to biomedical engineering students in the 6th semester (subject: Image Processing and Computer Graphics). Those techniques include automatic image segmentation methods. Traditionally, however, segmentation is performed manually, with the help of medical image analysis software. An example of such software is ITK-SNAP. ITK-SNAP is a non-commercial devoted to medical image segmentation. It allows to labels several structures at a time, visualize them, export the segmentation results for usage in different applications etc.

An MR scanner
http://www.cancerresearchuk.org/prod_consump/groups/cr_common/@cah/@gen/documents/image/scanner.jpg

The medical image used in this laboratory was acquired by magnetic resonance imaging (MRI). MRI is a non-invasive imaging technique. In the scanner, the patient is placed within a strong magnetic field.

Next, the hydrogen nuclei in the body are excited by radiofrequency (RF) pulses. The signal received when the nuclei relax depends on which tissue it comes from, since hydrogen nuclei bound to different other substances have slightly different properties. This allows to differentiate body structures via MRI.

Our image is a 3D image, i.e. it is composed of 96 flat (2D) images, called slices, which together create a stack – a discrete volume or a 3D image. The size of the voxel (basic brick of the image) is 0.78x0.78x2.5 mm. The image shows the abdomen.

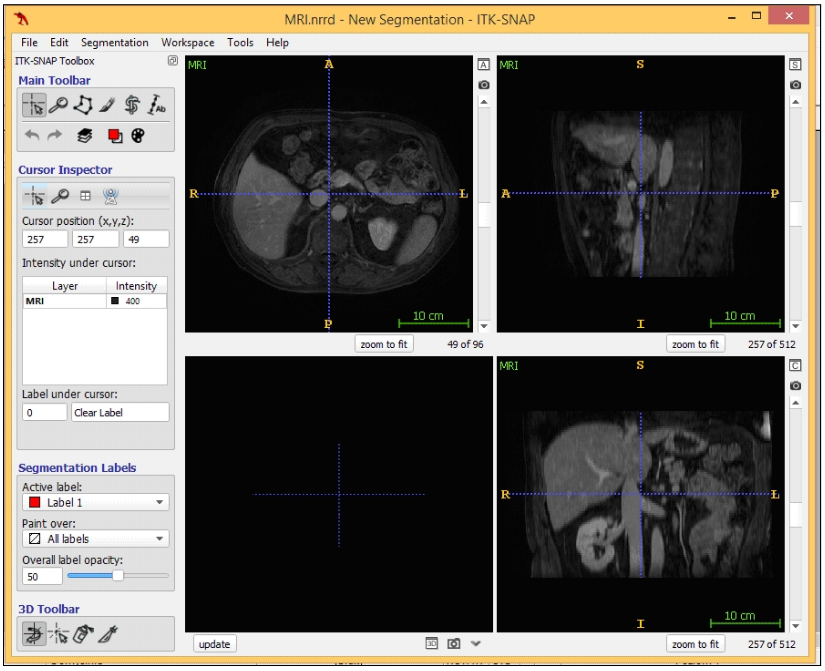
The aim of this laboratory is to identify several anatomical structures present in the image, segment and measure them.

2 Laboratory tasks

1. Open ITK-SNAP

2. To open an image: File – Open Main Image – Browse... choose the file MRI.nrrd. The File Format field will be set automatically. Next...

3. A summary of image parameters should appear. Finish.



Screen after main image loading

4. A window as in the figure above should appear on the screen. On the left, there is a toolbox for image manipulation, whereas on the right there are 4 windows, described below.

5. The upper left, upper right and bottom right corner of the right side of the window shows the same 3D image in 3 planes, axial, saggital and coronal, respectively. In the bottom left corner a visualization window is visible. In this window, the visualizations of the segmented structures are displayed.

6. Near the image display windows there are slider, used to set the current slice to be shown. Simulataneously, the intersection of the two dotted lines, pointing the current cursor location, is changing. The intersection point in all three image display windows reflect the same point in the 3D space.

7. Over the sliders, also button for maximizing the image display are available (denoted A-axial, S-saggital, C-coronal). The camera button allows to take a screenshot of the current window view and save it outside the application.

8. From the toolbar on the left, we will use the Main Toolbar and Inspector. The Main Toolbar allows to choose the edition mode, and the Inspector displays the properties of the current mode.
   (a) Crosshair mode – the user can move the cursor in one window, modifying the view in the other windows simultaneously.
   (b) Paintbrush mode – the user can draw labels (perform a segmentation) in the image windows. The available options in the Paintbrush Inspector are shape, size and other geometrical parameters of the brush (3D, isotropic)
   (c) Quick Label Picker – allows to choose the active label (colour) and scope of drawing (allows easier subsegmentation)
   (d) Label Editor – the user can edit labels, setting the corresponding colour and changing the name (e.g. change the colour of a label to red and its name to aorta)
9. To practise segmentation, set the axial view to slice z=50. Zoom the two round structures close to the middle of the slice (Zoom mode + right mouse button). Choose the Paintbrush Mode and brush on of the structure with Label 1. Change the active label to Label 2. Paint the second structure. Change the slice (slider or Page Down/Page Up with mouse over the window) and repeat the painting procedure. If you make a mistake, You can use the eraser by painting with the right mouse button.
10. Click Update below the visalization window (it is possible to check the Continous Update checkbox to automatically update the visualization after each use of the brush. The labelled structures will be displayed. You can move the coordinate system using the mouse.
11. To save the segmentations, Segmentation – Save Segmentation Image..../insert name (NiFTI format)/ Finish. The segmentation can be opened outside ITK-SNAP, e.g. Using ImageJ or MATLAB.
12. Clear the segmentations: Segmentation – Unload Segmentation
13. Here starts the main task: recognition and segmentation of image structures.
14. Using the atlas of anatomy, find the most important abdominal organs. Try to find them in the image using the knowledge about their shape and location. Label the organs using the Image Annotation (Text Annotation Mode). Save the screenshots of the slices with annotations. Put the slice number and plane in the name of the file.
15. After saving, delete the annotations: Selection Mode – Select All – delete
16. Now, using different labels for distinct organs or structures, segment them. Save the segmentation after (during) work.
17. Using the Segmentation – Volumes and Statistics option, save the volume of organs that you have found. Compare the values with literature-based reference values for different organs.

Tablica 1: Observed and normal organ volumes

Observed organ	MR Volume	Average volume