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Imaging Beyond Consumer Cameras – Proseminar (911.422)

Exercise sheet **A**

Exercise 1. 2 P.

Download the following ZIP file which contains an MRI image (`a01.nii.gz`) with a (manual) segmentation (`a01-seg.nii.gz`). The segmentation image only contains integers specifying to which anatomical structure each voxel belongs to.

Download by clicking

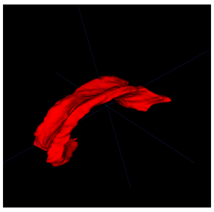
Figure out the image size (in voxel), the physical voxel size (in mm), the image orientation, the image origin and the range of the intensity values of the MRI image (`a01.nii.gz`). I recommend using **Convert3D** or **ITKSnap**, see .

Exercise 2. 2 P.

Using Convert3D, extract the middle transversal slice and save it (1) as a PNG (visualize this) and (2) as a `.nii` file. What could be the problem with the PNG image here? Provide the Convert3D command!

Exercise 3. 5 P.

Use the supplied XML file `Hammers_mith_atlases_n30r95_label_indices_SPM12_20170315.xml` to figure out the identifier of the *corpus callosum* and extract a binary volume that only contains a '1' at the location of the corpus callosum and '0' everywhere else (Hint: use `-thresh` of Convert3D). Visualize the corpus callosum in 3D (take a screenshot for instance) - this should look something like the image below.



Finally, use Convert3D to compute the volume of this structure (in mm^3). Provide all Convert3D commands!

Exercise 4. 6 P.

Show that binomial selection at the detector under a Poisson source yields another Poisson source. Then, illustrate the effect of the initial number of emitted photons on the signal-to-noise ratio (SNR). Details are given below.

Assume that an X-Ray source transmits photons of a certain energy. These photons pass through an object and hit a specific pixel on the detector. The X-Ray source is modelled by a Poisson random variable N with mean N_0. The probability mass function (PMF) of a Poisson distribution is

$$P[N = n] = \frac{1}{n!} e^{-N_0} N_0^n$$

where n is the number of events (photons) that occur with average rate N_0.

We model the detector as a Bernoulli random variable M with probability p. This is a reasonable model, since emitted photons either pass unaffected or interact with some object (independent events). We know that

$$P[M = m|N = n] = \binom{n}{m} p^m (1-p)^{n-m}$$

Your task is to derive the distribution of $P[M = m]$ (Hint: use total probability).

For your second subtask, note that the SNR is defined as

$$\text{SNR} = \frac{E[N]}{\sigma_N}$$

where σ_N is the standard deviation. *Now, what does this mean for our Poisson source?*

Total #points: 15 P.