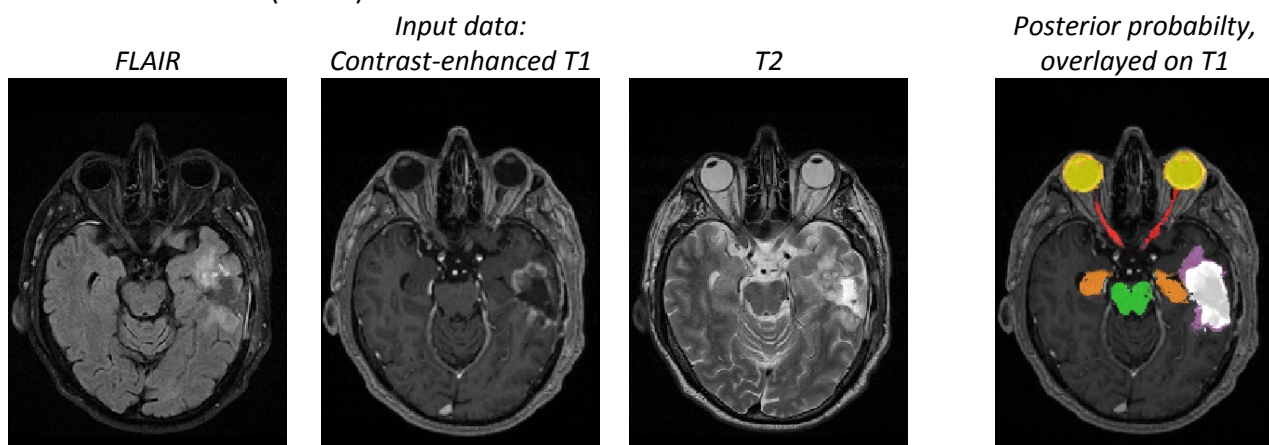


## MSc-project: Analysis of generative neural networks within a probabilistic tumor segmentation method

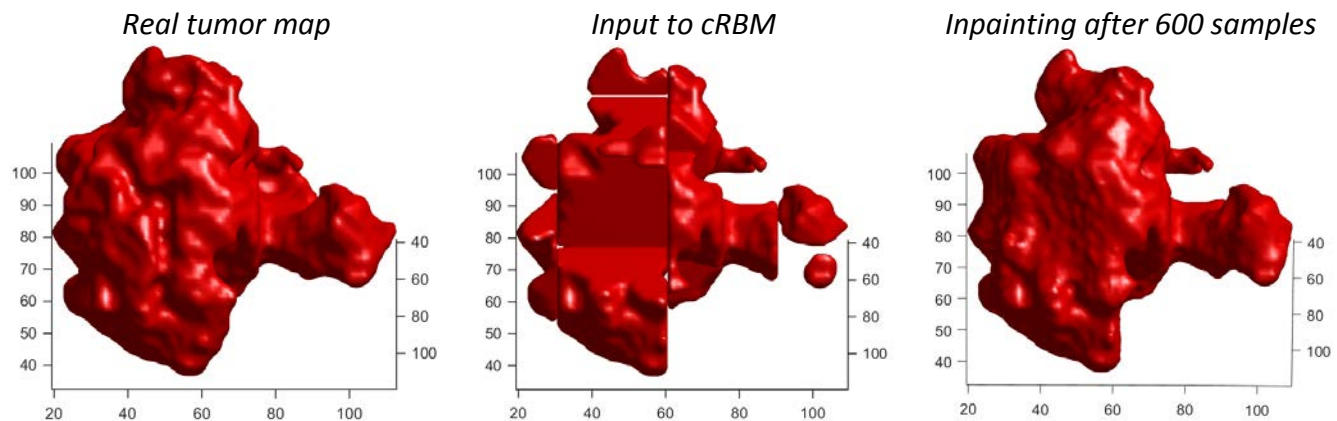
In brain tumor radiation therapy, the aim is to maximize the delivered radiation dose to the targeted tumor and at the same time minimize the dose to sensitive healthy structures – so-called organs-at-risk (OARs). When planning a radiation therapy session, the tumor and the OARs therefore need to be delineated on medical images of the patient's head, to be able to optimize a radiation dose plan. In clinical practice, the delineation is performed manually with limited assistance from automatic procedures, which is both time-consuming and typically suffers from poor reproducibility. There is, therefore, a need for computational methods that can segment both brain tumors and OARs fully automatically.

Automatically segmenting medical images of brain tumor patients is technically difficult for several reasons. Brain tumors in themselves are difficult to model, since they vary greatly in size, shape and location within the brain. The appearance of tumor tissue in medical images is also complicated due to varying biological changes both between tumors and within one tumor. Furthermore, healthy structures surrounding a tumor are pushed away and therefore greatly deformed by the growth of the tumor, due to the so-called mass effect. Finally, the available medical imaging techniques often result in imaging artifacts and in varying intensity properties across scans and imaging centers. For all these reasons, computational modeling of medical images for brain tumor patients is both a challenging and interesting task.

In this project, the student will work on improving an already functional automated segmentation method that handles both brain tumors and various OARs (see Figure 1). In a so-called generative approach, the aim is to build a probabilistic model of the formation process of the data to be segmented, and then “invert” this model to segment the data. The model consists of an adaptive model of the distribution of image intensities and various imaging artifacts, as well as a spatial model incorporating detailed prior knowledge of the spatial behavior of brain structures. In the existing implementation, healthy structures (including OARs) are modeled by a deformable probabilistic atlas, while tumors are modeled by a generative neural network – a so-called convolutional restricted Boltzmann machine (cRBM).



**Figure 1:** MR images of a brain tumor patient, together with the posterior probability of tumor and organs-at-risk obtained by the segmentation method.



**Figure 2:** Inpainting of a tumor (left) in which cuboid parts have been removed on purpose (middle), by sampling from the cRBM shape model (right).

Although the cRBM model is capable of modeling the spatial behavior and shape of tumors (see Figure 2), the model is still limited to represent local tumor shape only. In this project, the student will work on improving the global capability of the model, which should yield improved segmentation performance. This could be achieved with a generative neural network with a deeper architecture, such as a multi-layer variational autoencoder. The student is expected to research possible alternatives to the cRBM, implement and optimize these alternatives, and conduct comparative experiments on available data of brain tumor patients.

**Required qualifications:**

Knowledge of and/or interest in mathematical modeling, and programming skills (especially in MATLAB) are required. Having successfully followed a medical image analysis course (e.g., DTU course 02505 or similar) would be handy but is not necessary.

**Responsible institution:**

DTU Compute

**Contact information:**

Associate Professor Koen Van Leemput, DTU Compute (kvle@dtu.dk)

PostDoc Mikael Agn, DTU Compute (miag@dtu.dk)

**Allowed no of students per report:** 1-2

**Suggested DTU supervisor:**

Associate Professor Koen Van Leemput, DTU Compute (kvle@dtu.dk)

PostDoc Mikael Agn, DTU Compute (miag@dtu.dk)