Assignment 6 - Advanced ML for neuroimaging

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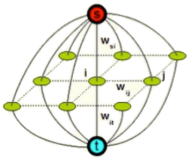
Exercise 1

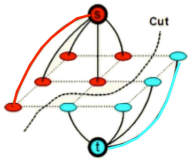
1. The 2D image 3x3 is shown below the pixels are normalised in the range (0,1) gray scale where 1 being white and 0 being black:

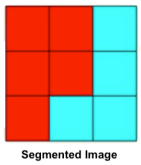
1	0.9	0.3
0.8	0.8	0.1
0.9	0.25	0.1

This is converted into graph along with source and sink nodes. Source node (s) corresponds to foreground and sink node (t) corresponds to background. As the graph cut based segmentation is an interactive procedure the foreground (red circle) and background pixel (blue circle) are assigned first from the image above. Below is the graphical represented of image to be segmented:



Here w_{ij} indicates the weight between the pixel nodes and w_{is} indicates the weight between source node and pixel nodes w_{jt} indicates the weight between sink node and pixel nodes. The cuts are made to segment the pixels in a optimal way using min cut/max flow technique which results in the below image (left) and the segmented image (right):





2. $E(Z^C) = D_p(Z_p^C) + V_{p,q}(Z_p^C, Z_q^C)$ is the Energy function. p,q are the nodes/pixels. The Energy function has two terms a. Data Term b. Smoothness

term. $D_p(Z_p)$ - is the data term. It defines the weight of the edge connecting the nodes/pixels to the source/sink. $w_{is} = D_i(s)$, $w_{jt} = D_j(t)$. It is a unary potential which characterises the probability of a node/pixel belonging to source or sink $V_{p,q}(Z_p, Z_q)$ is the smoothness term which defines the weight of edges connecting the nodes/pixels representing the image. $w_{ij} = V_{ij}(s,t)$. It is a pairwise potential which penalises pixels which have similar intensity(weight is close to zero) and for distinct pixels (intensity) the penalty is small / weights are larger (>0).

Exercise 2

(a) Labelled atlas: It is the type of atlas where one label, an integer value, per voxel indicating the anatomical structure or tissue present at that voxel.

(b) Probabilistic atlas: It is the type where one (probability) value (between 0 and 1) per voxel per anatomical structure or tissue represents a broad approximation of brain geometry and structure. It is used in combinawith intensity based segmentation.

(c) Probabilistic atlas is constructed by combining the atlas prior with intensity based information. Using Bayes Rule, P(Z|Y) = P(Y|Z) *P(Z) /P(Y) where Z = Label Assignments and Y= intensity information. P(Z|Y) is Posterior, P(Y|Z) is likelihood, P(Z) is prior and P(Y) is normalisation constant. Probabilistic atlas can be constructed by i) Density-Based Approaches, ii) Label-Based Approaches, iii) Deformation-Based Approaches.

Exercise 3

(a) Instead of using only a single atlas or a model-based average representation, multi-atlas segmentation utilizes the entire dataset of expert annotated atlases as training data.This helps in capturing high morphological variability and thus higher segmentation accuracy. It is composed of two steps - label transfer from manually annotated atlases to a new image and label fusion to decide the label prediction. A basic assumption made is that the images are accurately registered/aligned in a common coordinate system before performing segmentation.

(b) All atlases need to be registered to a single template before segmentation. Thus, with infinite atlases, the likelihood of errors in registration increases. Therefore, segmentation error cannot reduce to zero.