Semi-automatic identification of neurosurgically important white matter tracts using fMRI+DTI atlas

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Project Summary: There are a number of challenges to optimization of brain tumor resection: the surgeon requires a complete and accurate map of the complex and critical functional anatomy of the patient's individual brain including the relationship to the tumor. It can be particularly difficult to determine the location of critical grey and white matter structures when they have been displaced by the tumor. Functional MRI and Diffusion Tensor Imaging are complementary techniques which can provide information about critical cortical processing areas, associated white matter (WM) connections (tracts) and their relationship to the lesion. In this project we are harnessing emerging methods to improve the sensitivity and specificity of fMRI and DTI for delineation of functional organization in individual patient brains. Our strategy is to combine information from fMRI and DTI into a model (an atlas) that can be applied to patients to better define the crucial WM tracts.

Progress: We have developed a new type of fMRI+DTI atlas that represents the spatial relationship between functional activations and white matter tracts (Figure 1). We call our method the relative distance (RD) atlas. The advantage of our new model is that it is relatively robust to displacement of fiber tracts and activations by a tumor, so this type of atlas can be used for neurosurgical planning in patients with mass lesions.

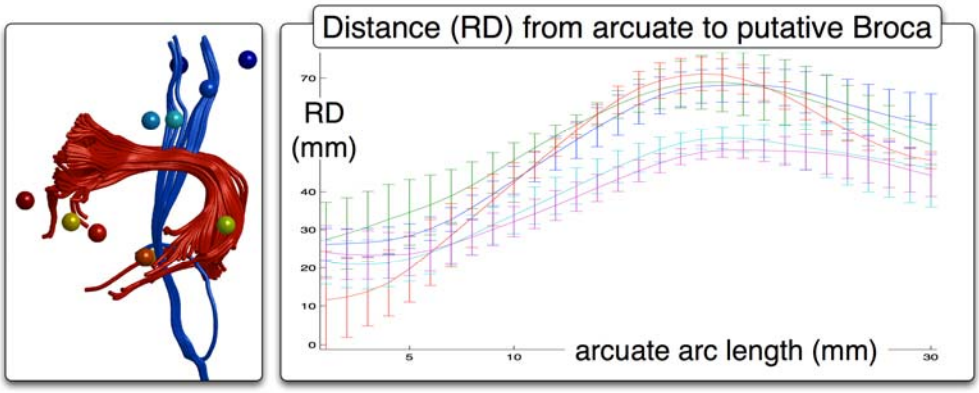

Figure 1: Measurement of fMRI+DTI atlas model

Milestone: We have recently shown that the novel RD atlas can be used to *detect* white matter tracts in patients (Figure 2), based on the locations of their functional activations

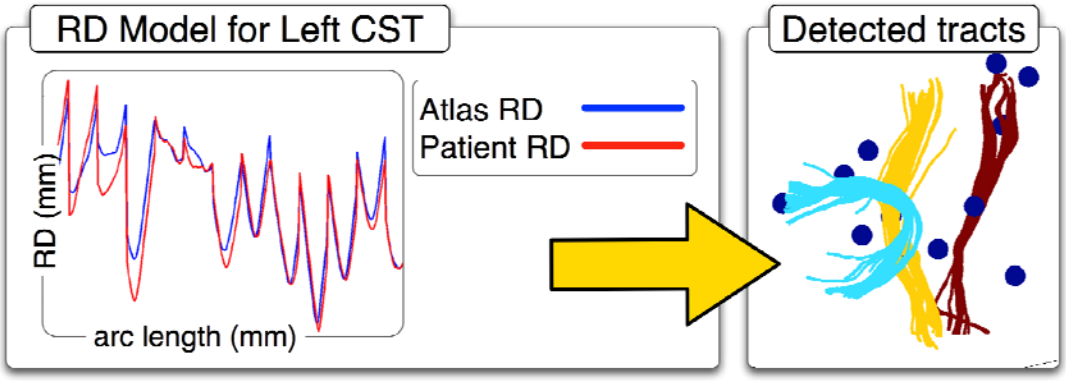

Figure 2: Use of fMRI+DTI atlas model (left) to detect fiber tracts (right)

(O'Donnell et al. HBM 2010). In all three test patients, the corticospinal (motor) tract was detected in both hemispheres. The arcuate fasciculus (language) was detected fully in 1 patient and partially in 2 patients.

Milestone: We have also demonstrated that this type of atlas may be used to *predict* locations of fiber tracts in patients. This may be of use in brain areas with edema (swelling) or tumor infiltration where fiber tracking gives partial results.

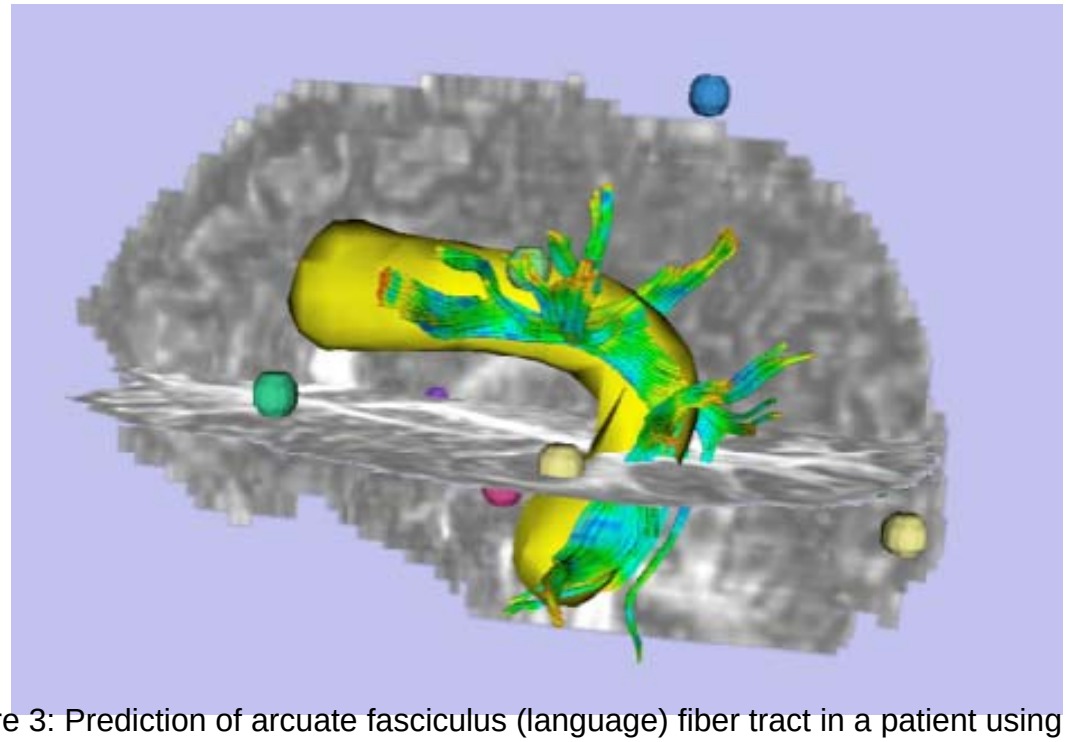

Figure 3: Prediction of arcuate fasciculus (language) fiber tract in a patient using fMRI+DTI atlas model. Predicted location is in yellow, with nearby fibers in multicolor.

New Grant Support: Based on this work, grant support has been secured (PI Lauren O'Donnell) from CIMIT to continue work on white matter atlases, with application to traumatic brain injury. We have applied for an NIH R21 grant (PIs Alexandra Golby and Lauren O'Donnell) to further fund the effort on detection of white matter fiber tracts for neurosurgical planning. We have received a very good score, but 2 percentile points away from the funding line. Thus we will resubmit the application, hoping that we receive funding.