Application for Round-6 QIBA Project Funding

Title of Proposal: Methodology and Reference Image Set for Lesion Characterization in Terms of Texture and Morphology		
QIBA Committee/Subgroup:		
NIBIB Task Number(s) which this project addresses:		
Project Coordinator or Lead Investigator Information:		
Last Name: Samei	First Name: Ehsan	Degree(s): PhD
e-mail:	Tel #:	
Institution/Company: Duke University Medical Center		
Amount Requested:		

Project Description

Lesion characteristics offer a wealth of information about its phenotype and the progression of the disease or the treatment. Meaningful quantitative characterization of the lesion can thus be invaluable in disease classification and management. In the area of CT lesion characterization, most of the QIBA effort thus far has been focused on volume estimation. While volumetry is essential for effective lesion characterization, lesion volume is only one of several features that could be used to describe its radiological phenotype. Beside volume, there are three additional attributes that are considered as important, if not more important, in the phenotypical characterization of a lesion: morphology (including shape and boundary conditions), density, and internal heterogeneity (i.e., lesion texture). These attributes can be of significant clinical diagnostic and prognostic value.

One of the major challenges in lesion characterization is lack of access to the ground truth. The true nature of a clinical lesion is nearly impossible to ascertain. As such, most prior efforts to evaluate lesions have either focused on assessing change (e.g., change in the volume of a lesion), or relied on physical phantoms which can offer ground truth but fall short in accurately modeling real anatomical heterogeneities and diseased conditions.

Built upon a substantial track record of research in the development of virtual lesions, the objective of the present project is to develop hybrid clinical CT images containing virtual lesion models with known-exactly morphology and texture. This database will be used to investigate the accuracy of lesion quantification in terms of texture and morphology, thereby extending quantitative CT from volumetry to include additional features. This project is justified based on the well-established fact that lesion morphology and texture are clinically relevant to cancer characterization. However, due to lack of ground truth in traditional clinical databases, it has thus far been impossible to assess the accuracy with which morphological and textural phenotypic expressions can be accurately characterized. This project directly addresses this shortcoming by providing a database with ground truth. The work contributes to existing and emerging QIBA Profiles by assessing the impact of lesion morphology on volume quantification. It further advances the QIBA trajectory into new areas where quantitative imaging can meaningfully impact medical research and care, paving the way towards new Profile definitions.

Using a virtual insertion of realistic 3D lesions into clinical CT images, we will develop an image database that allows for comprehensive quantitative characterization of lesion features in CT. The dataset will provide anatomical variability as exists in actual clinical datasets, while at the same time the pre-defined lesion models with a priori known properties will offer the advantage of providing the ground truth. Furthermore, this platform will allow for a variety of datasets to be generated with multiple degrees of flexibility in key investigational areas including statistical variability of lesion models (size, shape, etc.) or repeated insertions of the same or different lesions at various insertion locations.

We will incorporate texture and morphology, two burgeoning areas of quantitative characterization in our lesion modeling and insertion framework. The framework will enable coupling statistical texture modeling with an analysis of lesion morphology to determine how measured lesions estimates (e.g., Haralick texture features or Hausdorff morphology deformations) are informed by the imaging system optics and reconstruction. The deliverables include 1) the development of virtual lesions with morphological and textural variability, 2) a database of hybrid clinical image sets with lung nodules and liver lesions for morphology and texture analysis, both data sets with confirmed and validated added lesions for gold-standard quantitative evaluation, and 3) a systematic analysis of the impact of CT image acquisition and reconstruction on lesion quantification in terms of volume, texture, and morphology. Developed for in the execution of this project, this will be established as a platform for multi-software analysis of lesion features.