Radiology screening is proved to be a vital step for cancer detection in many applications. However, human errors stay as a significant issue in this process. Missing cases and over-diagnosis can have serious outcomes and increase mortality rate. Computer aided diagnosis (CAD) tools help radiologists to reduce diagnostic errors such as missing tumors and misdiagnosis.

In this dissertation, we aim to develop a paradigm shifting CAD system, called collaborative CAD (C-CAD), that unifies CAD and eye-tracking systems in realistic radiology room settings. We propose a novel graph-based analysis as our collaboration medium between the radiologist and our machine learning algorithms for medical image analysis.

We first developed an eye-tracking interface providing radiologists with a real radiology room experience. Further, we develop a graph-based clustering and sparsification algorithm to transform eye-tracking data (gaze) into a graph model to interpret patterns quantitatively and qualitatively.

Second, we develop a local image analysis algorithm. Once we extracted radiologists’ ROIs, using our graph formulation, we incorporate our deep learning algorithm to locally analyze radiologists ROIs. We first show this process with a pilot study. Then, we develop a semi-supervised multi-task network to perform segmentation and diagnosis of abnormalities in the ROIs jointly. The specific design of our algorithm, in this step, targets two critical challenges in medical image analysis: generalization and lack of large scale annotated data for training.

Finally, we introduce two global image analysis modules. The global image analysis modules will help for a better screening by handling the areas that are totally missed by radiologists during the screening. The goals of global modules are: 1) Capturing tiny abnormalities that can be missed during the screening process, and 2) performing structure/organ segmentation to better guide the radiologists for high risk areas in case of abnormalities in organs with complex shape.