Medical image segmentation is one of the fundamental processes to understand and assess the functionality of different organs and tissues as well as quantifying diseases and helping treatment planning. With ever increasing number of medical scans, automated, accurate, and efficient medical image segmentation is an unmet need for improving healthcare. Recently, deep learning has emerged as one of the most powerful methods for almost all image analysis tasks such as segmentation, detection, and classification and so in medical imaging. In this regard, this dissertation introduces new algorithms to perform medical image segmentation for different (a) imaging modalities, (b) number of objects, (c) dimensionality of images, and (d) under varying labeling conditions.

First, we study dimensionality problem by introducing a new 2.5D segmentation engine that can be used for single and multi-object setting. We propose new fusion strategies as well as loss functions for deep neural networks to generate satisfactory delineations.

Later, we expand the proposed idea into 3D and 4D medical images and develop a “budget (computational) friendly” architecture search algorithm to make this process self-contained and fully automated without sacrificing accuracy. Instead of manual architecture design, which is often based on plug-in and out and expert experience, the new algorithm provides an automated search of successful segmentation architecture within a short period of time.

Finally, we study further optimization algorithms on label noise issue and improve overall segmentation problem by incorporating prior information about label noise and object shape information. For the first time in literature, we obtained shape prior from inexpert and noisy labels by deep geodesic features and incorporate obtained prior in the segmentation network to do expert-level annotation by using inexpert labels.

We conclude the thesis work by studying different network and hyperparameter optimization settings that are fine-tuned for varying conditions for medical images in particular. The optimization methods as the engine of deep networks in training are studied and introduced for medical image segmentation. Applications are chosen from cardiac scans (images) and efficacy of the proposed algorithms are demonstrated on several data sets.