Abstract: Medical image segmentation plays a crucial role in delivering effective patient care in various diagnostic and treatment modalities. Manual delineation of target volumes and all critical structures is a very tedious and highly time-consuming process and introduce uncertainties of treatment outcomes of patients. Fully automatic methods holds great promise for reducing cost and time, while at the same time improving accuracy and eliminating expert variability, yet there are still great challenges. Legally and ethically, human oversight must be integrated with "smart tools" favoring a semi-automatic technique which can leverage the best aspects of both human and computer.

In this work we show that we can formulate a semi-automatic framework for the segmentation problem by formulating it as an energy minimization problem in Conditional Random Field (CRF). We show that human input can be used as adaptive training data to condition a probabilistic boundary term modeled for the heterogeneous boundary characteristics of anatomical structures. We demonstrated that our method can effortlessly adapt to multiple structures and image modalities using a single CRF framework and tools to learn probabilistic terms interactively. Additionally, We developed a new ensemble one-vs-rest graph cut algorithm for multi-class segmentation that outperformed a label swapping multi-class graph cut both in time and accuracy. We include some work using deep learning for medical image segmentation and indicate how we could generalize our CRF framework to incorporate that.

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