

Abstract

Magnetic resonance (MR) neuroimaging is an active field in investigating brain structures and functions. After decades of development, the whole pipeline of MR neuroimaging tends to become mature, but many essential steps still faces challenges and difficulties, especially in the accuracy of the image segmentation, image generation and data prediction. Recently, the revival of deep neural networks made immense progress in the field of machine learning. The proposal of Bayesian deep learning further enabled the ability of uncertainty generation in deep learning prediction. In this work, we proposed and developed different kinds of Bayesian neural networks to improve the accuracy of brain segmentation, brain image synthesis, and brain function related behavior prediction. To overcome the challenges in brain segmentation, we proposed a fully-automated brain extraction pipeline combining deep Bayesian convolutional neural network (CNN) and fully connected three-dimensional (3D) conditional random field (CRF). To increase the image synthesis accuracy and improve the calibration of the model uncertainty, we proposed a Bayesian conditional generative adversarial network (GAN). To improve the brain function related behavior prediction, we proposed a Bayesian deep neural network (DNN), and a feature extraction and ranking method for it. Experiments were done on real data to validate the proposed methods. The comparison between our methods and the state-of-the-arts showed that our methods can significantly improve the testing accuracy and the behavior of the model uncertainty generated by the Bayesian neural networks matches our expectation.