Alma Mater Studiorum · University of Bologna

School of Science
Department of Physics and Astronomy
Master Degree in Physics

3D U-NET DOMAIN GENERALIZATION IN FETAL BRAIN MRI SEGMENTATION

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Abstract

This work investigates domain generalization of a 3D U-Net (nnU-Net v2.4.1, ResEncM) for fetal brain MRI segmentation across three datasets with different characteristics: Kispi-mial, Kispi-irtk, and dHCP. The causality-inspired augmentation GIN-IPA was integrated into the nnU-Net training loop, and three strategies were compared: default nnU-Net augmentation, GIN-IPA augmentation alone, and their combination. Models are trained on each dataset and evaluated both in-domain and out-of-domain using Dice score, volume similarity and Hausdorff distance. Two main conclusions emerge. First, dataset quality and scale dominate generalization: training on dHCP yields consistently stable performance across domains, largely insensitive to the augmentation recipe. Second, GIN-IPA provides gains, but only when the source lacks the target variability: with training on Kispi-irtk and inference on dHCP, all the performance metrics rise significantly. Instead, stacking default augmentation with GIN-IPA is not additive and can be detrimental. Limitations include a general small availability of public data and label-set harmonization. The results argue for prioritizing multicentre, high-quality fetal MRI with standardized SR reconstruction; within constrained settings, GIN-IPA may represent a useful and pragmatic choice for single-source domain generalization.