

A COMPARISON STUDY OF U-NET BASED METHODS FOR BRAIN TUMOR SEGMENTATION

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Abstract

The brain tumor segmentation (BraTS) Challenge is an international competition that focuses on the task of automated segmentation of the different parts of brain tumors in magnetic resonance imaging (MRI) scans.

U-Net architecture has become the de-facto standard for medical image segmentation tasks, and the proposals based on this architecture have been among the top-ranked solution proposals in the last editions.

The 2023 edition of the BraTS challenge introduced a set of 4 new datasets towards addressing additional populations (e.g., sub-Saharan Africa patients) and types of tumors (e.g., meningioma).

The goal of this thesis is to train and test different U-Net based architectures using the datasets of the 2023 edition, and to compare and analyse the performance of the different methods both quantitatively and qualitatively.

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Appendix A

Adult dataset: Results per fold

A.1 Baseline nnU-Net

Baseline nnU-Net	Dice Coefficient			95% Hausdorff Distance		
	WT	TC	ET	WT	TC	ET
Fold 1	0.9318	0.9069	0.8556	3.779	6.862	11.877
Fold 2	0.9361	0.9054	0.8749	4.489	6.521	11.727
Fold 3	0.9332	0.9213	0.8882	3.286	4.535	5.337
Fold 4	0.9348	0.9246	0.8710	3.771	4.050	11.111
Fold 5	0.9386	0.9217	0.8640	2.958	2.845	12.509
Average	0.9349	0.9160	0.8707	3.857	4.5626	10.5128

Table A.1: Baseline nnU-Net fold results

A.2 Custom nnU-Net ensemble

Custom nnU-Net Isensee	Dice Coefficient			95% Hausdorff Distance		
	WT	TC	ET	WT	TC	ET
Fold 1	0.9250	0.8969	0.8490	6.299	8.489	13.48
Fold 2	0.9353	0.9162	0.8937	5.125	4.486	4.180
Fold 3	0.9259	0.9068	0.8769	5.456	6.698	8.419
Fold 4	0.9324	0.9174	0.8714	5.273	5.804	12.491
Fold 5	0.9320	0.9040	0.8731	4.354	7.670	9.678
Average	0.9301	0.9083	0.8728	5.301	6.829	9.849

Table A.2: Custom nnU-Net Isensee et al. fold results

Custom nnU-Net Luu	Dice Coefficient			95% Hausdorff Distance		
	WT	TC	ET	WT	TC	ET
Fold 1	0.9278	0.9062	0.8475	5.144	5.248	11.971
Fold 2	0.9370	0.9084	0.8843	4.996	7.893	7.430
Fold 3	0.9269	0.9113	0.8770	5.423	5.442	6.499
Fold 4	0.9255	0.9120	0.8662	4.790	8.975	14.380
Fold 5	0.9321	0.9200	0.8672	4.117	2.915	9.908
Average	0.9298	0.9116	0.8684	4.894	6.8946	10.2378

Table A.3: Custom nnU-Net Luu et al. fold results

Custom nnU-Net	Dice Coefficient			95% Hausdorff Distance		
	WT	TC	ET	WT	TC	ET
Fold 1	0.9275	0.9062	0.8527	4.613	5.276	13.211
Fold 2	0.9382	0.9111	0.8921	4.812	7.602	5.577
Fold 3	0.9281	0.9116	0.8787	5.518	6.673	8.629
Fold 4	0.9302	0.9162	0.8697	5.825	7.289	12.726
Fold 5	0.9344	0.9190	0.8696	3.917	2.799	9.843
Average	0.9316	0.9122	0.8725	4.557	5.728	9.797

Table A.4: Custom nnU-Net ensemble fold results

A.3 Swin UNETR

Swin UNETR	Dice Coefficient			95% Hausdorff Distance		
	WT	TC	ET	WT	TC	ET
Fold 1	0.9235	0.8928	0.8490	4.732	7.655	10.977
Fold 2	0.9350	0.9117	0.8797	4.554	7.647	11.340
Fold 3	0.9270	0.9109	0.8723	4.624	3.683	7.459
Fold 4	0.9278	0.9126	0.8569	4.119	3.185	14.421
Fold 5	0.9333	0.9137	0.8587	3.806	4.812	12.933
Average	0.9293	0.9084	0.8633	4.367	5.396	11.426

Table A.5: Swin UNETR fold results

A.4 Adversarial U-Net

Adversarial U-Net	Dice Coefficient			95% Hausdorff Distance		
	WT	TC	ET	WT	TC	ET
Fold 1	0.9075	0.8689	0.8154	8.223	11.291	16.962
Fold 2	0.9174	0.8807	0.8562	6.358	9.296	12.428
Fold 3	0.8987	0.8745	0.8510	13.973	13.164	8.809
Fold 4	0.9046	0.8946	0.8281	11.540	8.480	18.372
Fold 5	0.9050	0.8875	0.8292	9.909	8.976	17.316
Average	0.9066	0.8812	0.8360	10.6006	10.8414	14.9774

Table A.6: Adversarial U-Net fold results

Appendix B

Training plots

B.1 Africa

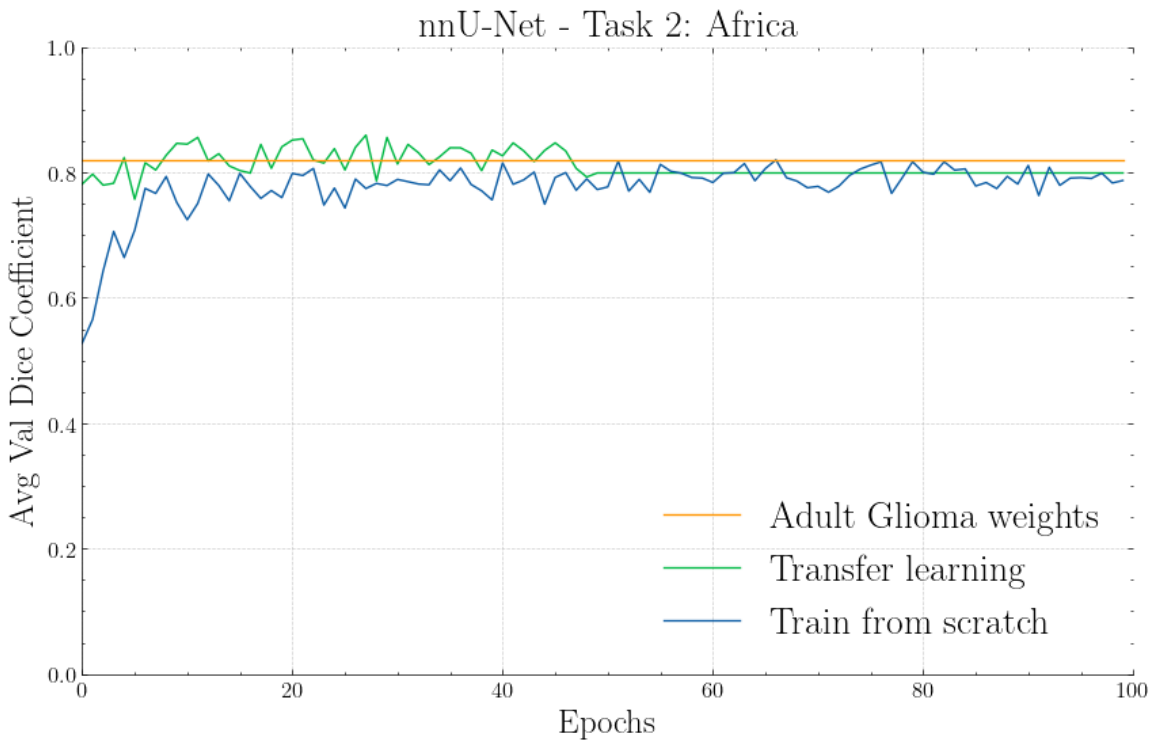

Figure B.1: Average Validation Dice Coefficients for the nnU-Net method with the three different approaches of Phase 2

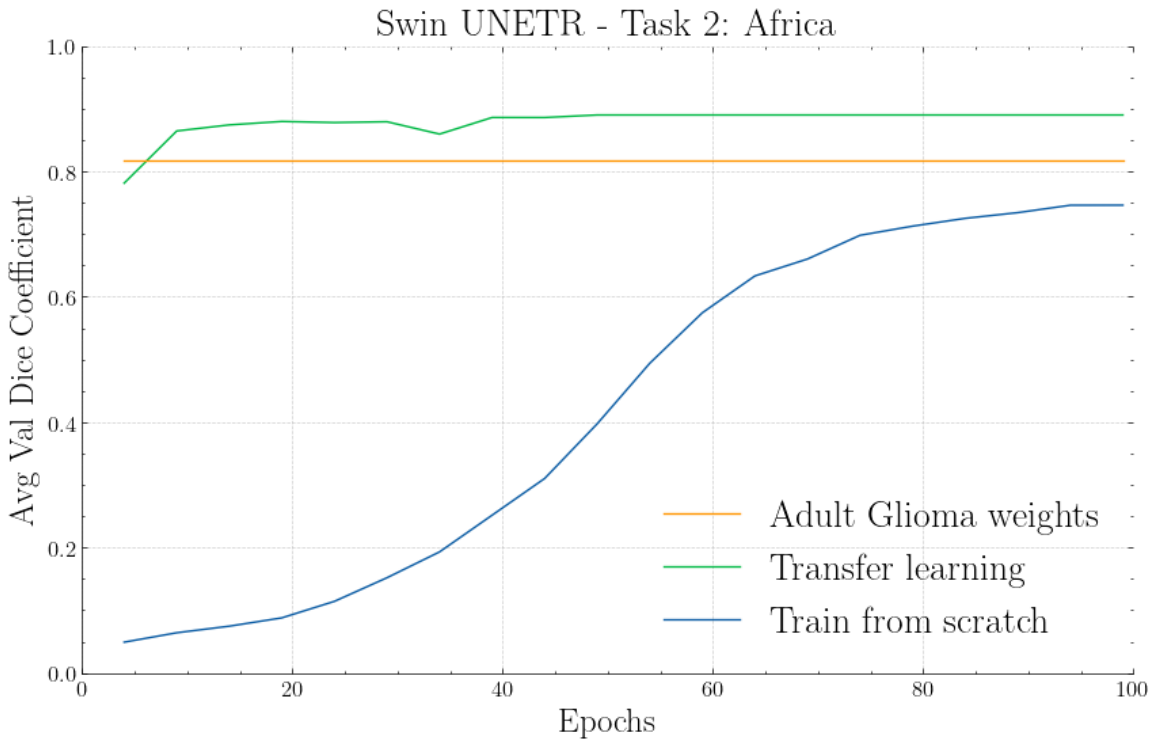

Figure B.2: Average Validation Dice Coefficients for the Swin UNETR method with the three different approaches of Phase 2

B.2 Meningioma

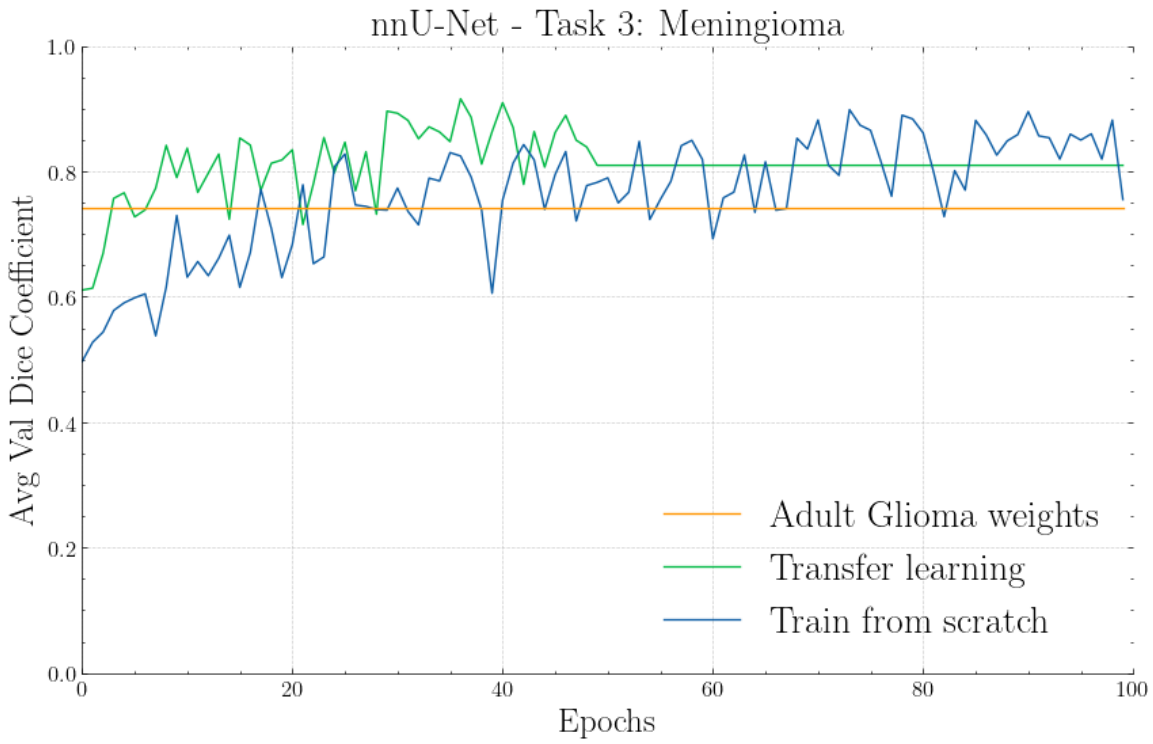

Figure B.3: Average Validation Dice Coefficients for the nnU-Net method with the three different approaches of Phase 2

Figure B.4: Average Validation Dice Coefficients for the Swin UNETR method with the three different approaches of Phase 2

B.3 Metastases

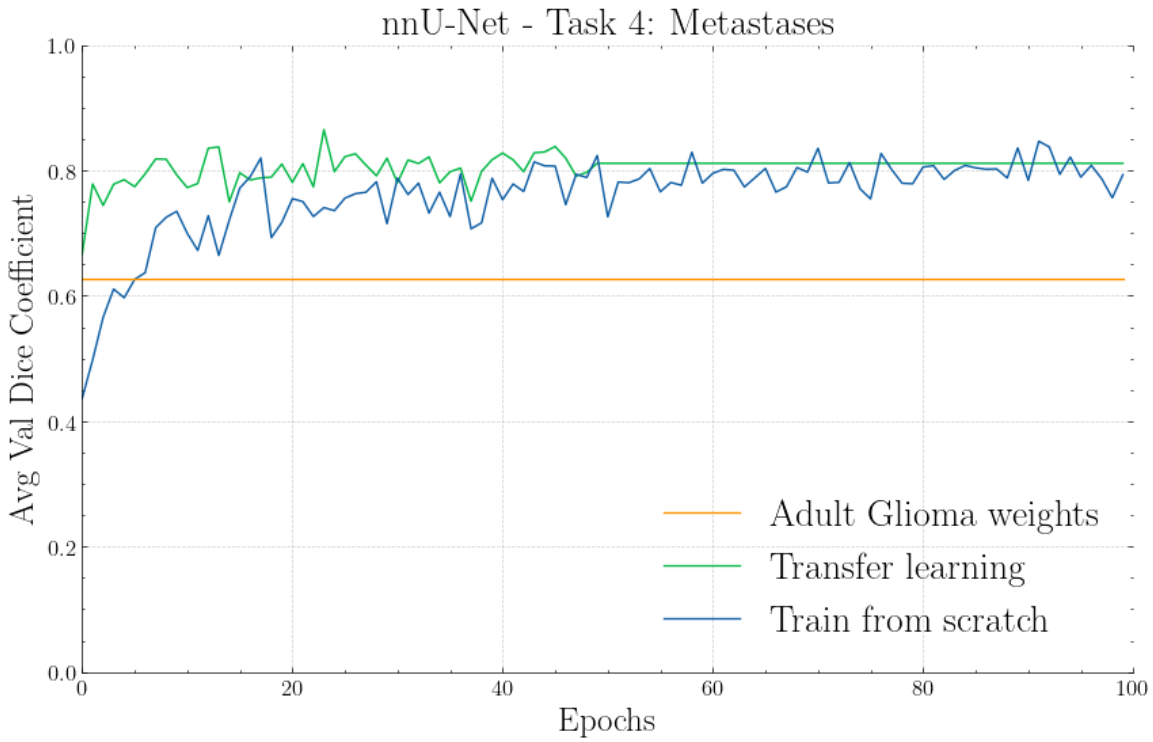

Figure B.5: Average Validation Dice Coefficients for the nnU-Net method with the three different approaches of Phase 2

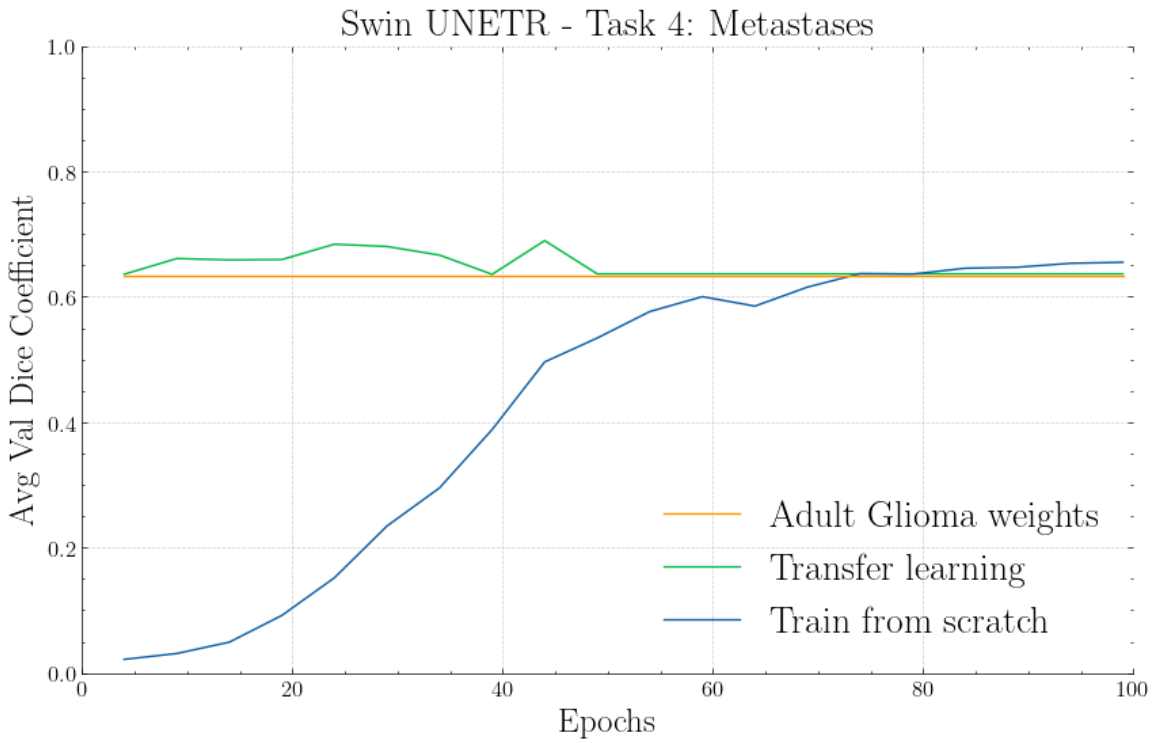

Figure B.6: Average Validation Dice Coefficients for the Swin UNETR method with the three different approaches of Phase 2

B.4 Pediatric

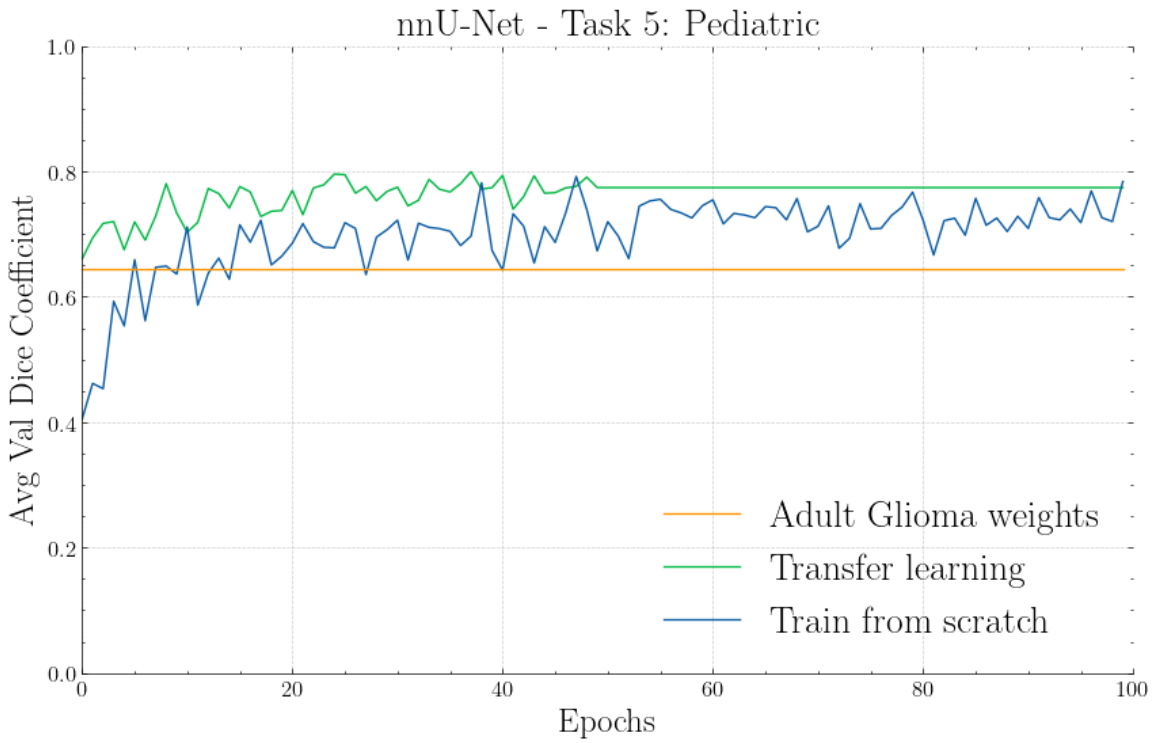

Figure B.7: Average Validation Dice Coefficients for the nnU-Net method with the three different approaches of Phase 2

Figure B.8: Average Validation Dice Coefficients for the Swin UNETR method with the three different approaches of Phase 2