Appendix A. Complete results of bidirectional learning

This appendix contains the complete results of all architectures, methods and datasets.

Table 1: Results of bidirectional propagation of errors on MNIST. Selected iteration with best accuracy test. Bold numbers are the best results for each model.

Model	Learning	Accuracy test	Accuracy noisy	Accuracy adversarial	Sigmoid rate	Softmax rate
Fully connected	BP	**0.9289**	**0.7519**	0.039	4.18E-13	1
no hidden	BL then BP	0.9202	0.3469	0.0781	**0**	1
layer	BL	0.8854	0.7229	**0.4018**	**0**	1
Fully connected	BP	**0.9273**	**0.7138**	0.0417	3.34E-12	1
no hidden	BL then BP	0.9265	0.3216	0.045	**0**	1
layer & no bias	BL	0.8781	0.6419	**0.6014**	**0**	1
Fully connected	BP	**0.9484**	**0.6478**	0.0314	0.996	0.9452
one hidden	BL then BP	0.9397	0.407	0.0949	**0.9811**	**0.5458**
layer	BL	0.9176	0.412	**0.1148**	0.9834	0.5935
Fully connected	BP	**0.9456**	**0.6502**	0.0318	0.9983	0.984
one hidden	BL then BP	0.9338	0.3807	0.06	0.9923	0.6429
layer & no bias	BL	0.905	0.5148	**0.0814**	**0.5**	**0.1**
Fully connected	BP	**0.9451**	0.4826	0.0506	0.9999	0.9999
two hidden	BL then BP	0.9247	**0.6984**	**0.3476**	**0**	0.9239
layers	BL	0.9042	0.6425	0.2211	7.57E-10	**0.8227**
Fully connected	BP	**0.9477**	0.6051	0.0413	0.9999	0.9995
two hidden	BL then BP	0.9279	**0.7474**	**0.3171**	**4.67E-11**	0.987
layers & no bias	BL	0.9038	0.6496	0.1702	0.000146	**0.4785**
Fully connected	BP	**0.9803**	**0.938**	0.0981	0.9998	0.9999
four hidden	BL then BP	0.9458	0.8653	**0.3329**	**0.9975**	**0.9896**
layers	BL	0.9458	0.8653	**0.3329**	**0.9975**	**0.9896**
Fully connected	BP	**0.9815**	**0.901**	0.1094	0.9998	0.9999
four hidden	BL then BP	0.9415	0.7891	**0.2793**	0.9997	0.9946
layers & no bias	BL	0.9439	0.7186	0.2626	**0.9991**	**0.9596**
CNN	BP	**0.9893**	**0.9883**	**0.1226**	1	1
three conv.	BL then BP	0.9785	0.8559	0.0804	**0.9866**	**0.9984**
layers	BL	0.9799	0.8369	0.068	0.987	**0.9984**
CNN	BP	**0.9898**	**0.989**	0.1976	1	1
three conv.	BL then BP	0.977	0.7643	**0.2489**	**4.67E-05**	1
layers & no bias	BL	0.9813	0.9346	0.2415	0.5	**0.9982**

Table 2: Results of hybrid adversarial networks on MNIST. Selected iteration with best accuracy test. Bold numbers are the best results for each model.

Model	Learning	Accuracy test	Accuracy noisy	Accuracy adversarial	Sigmoid rate	Softmax rate
Fully connected	BP	**0.9792**	**0.927**	0.0131	1	1
one hidden	BL then BP	0.9786	0.8736	**0.1414**	1	0.987
layer	BL	0.9652	0.7719	0.0682	**0.9889**	**0.7518**
Fully connected	BP	**0.9799**	**0.9333**	0.0524	**0**	1
one hidden	BL then BP	0.9621	0.5618	**0.6973**	1	1
layer & no bias	BL	0.9503	0.4872	0.5338	1	1
CNN	BP	**0.9925**	**0.9913**	0.0477	1	1
two conv.	BL then BP	0.9854	0.9783	**0.9375**	1	1
layers	BL	0.9823	0.9696	0.9084	1	1
CNN	BP	**0.9921**	**0.9906**	0.0508	1	1
two conv.	BL then BP	0.9849	0.9768	**0.9592**	1	1
layers & no bias	BL	0.9829	0.9491	0.9566	1	1

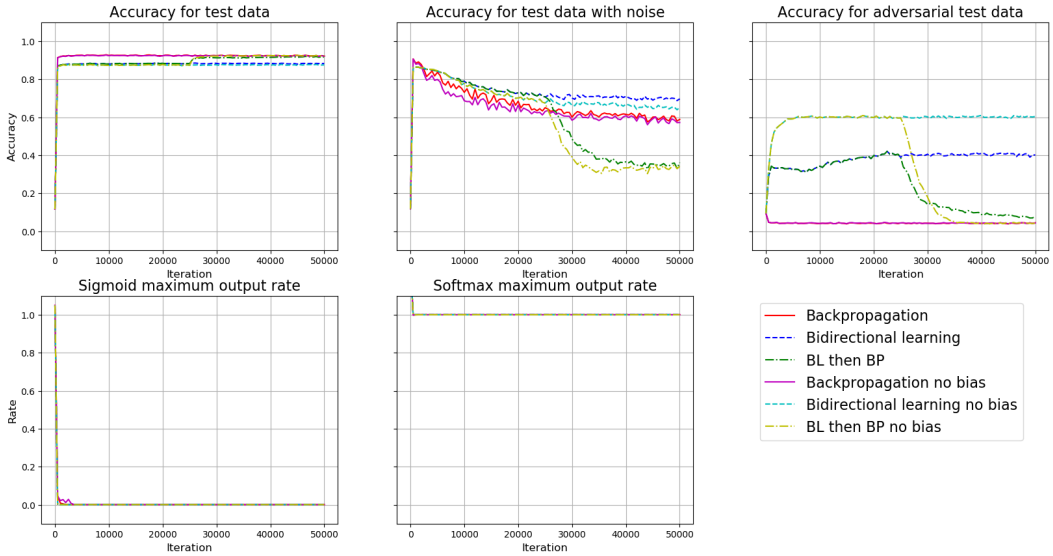

Figure 1: Results of bidirectional propagation of errors through the iterations of fully connected neural network without hidden layer on MNIST dataset.

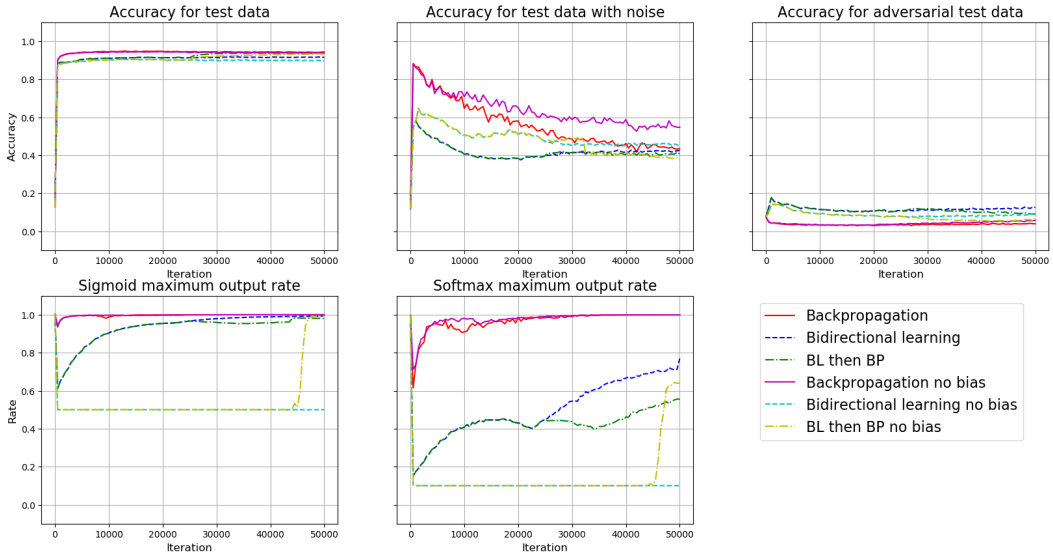

Figure 2: Results of bidirectional propagation of errors through the iterations of fully connected neural network with one hidden layer on MNIST dataset.

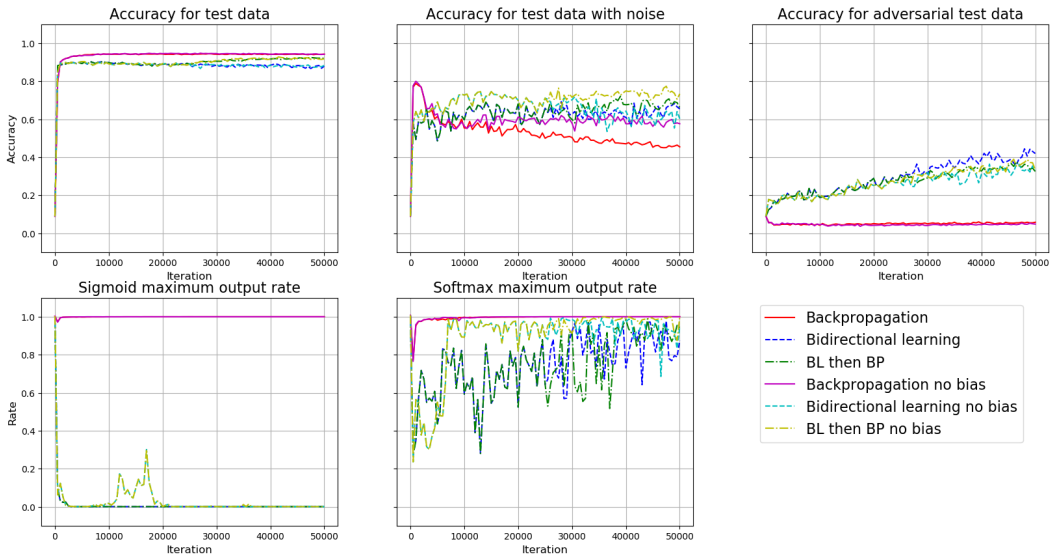

Figure 3: Results of bidirectional propagation of errors through the iterations of fully connected neural network with two hidden layers on MNIST dataset.

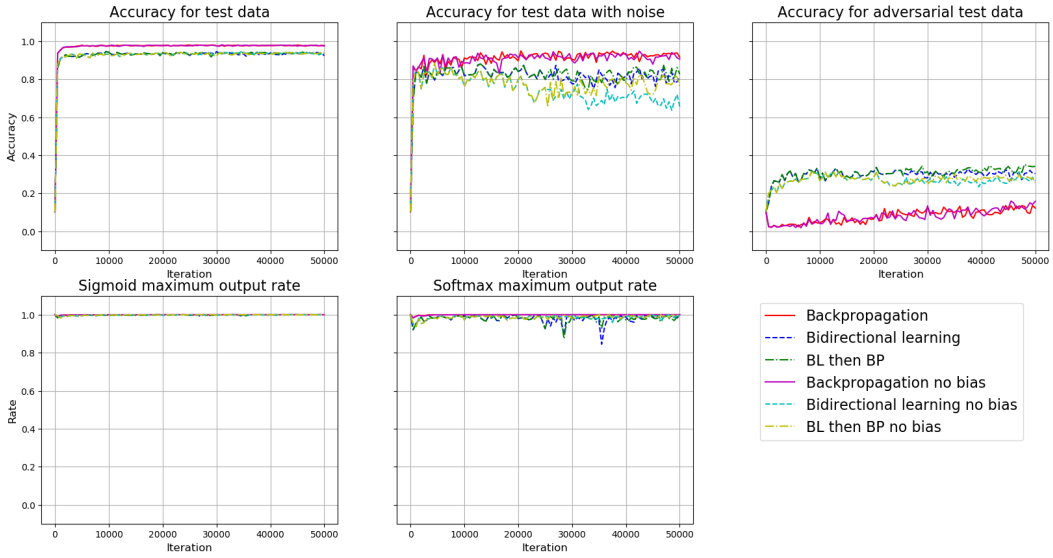

Figure 4: Results of bidirectional propagation of errors through the iterations of fully connected neural network with four hidden layers on MNIST dataset.

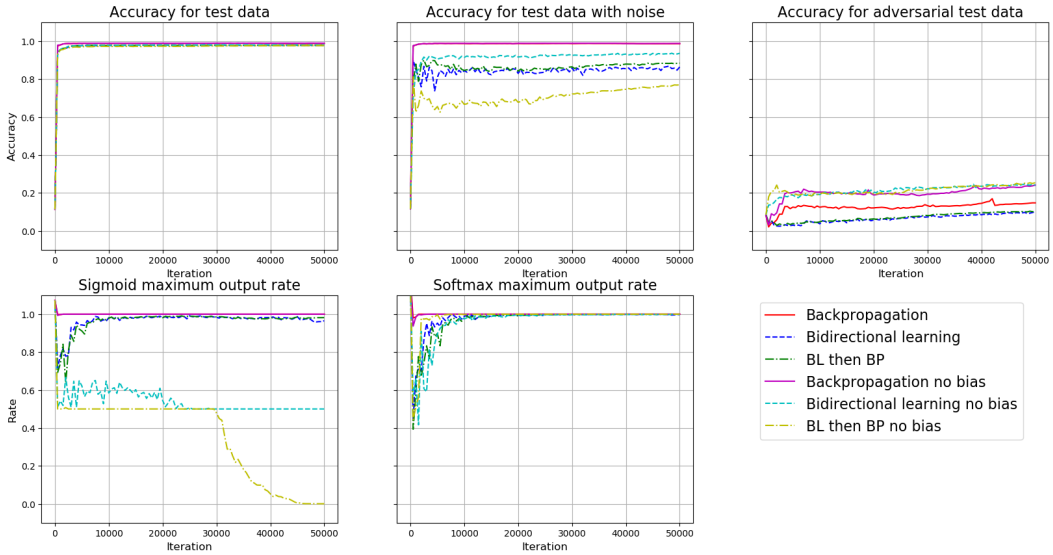

Figure 5: Results of bidirectional propagation of errors through the iterations of convolutional neural network with three convolutional layers on MNIST dataset.

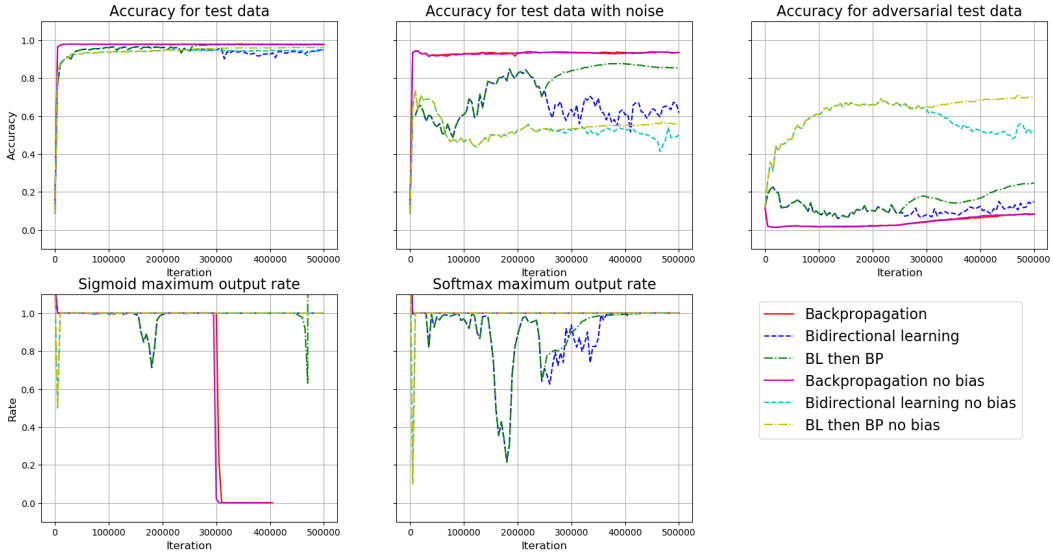

Figure 6: Results of hybrid adversarial network through the iterations of fully connected neural network with one hidden layer on MNIST dataset.

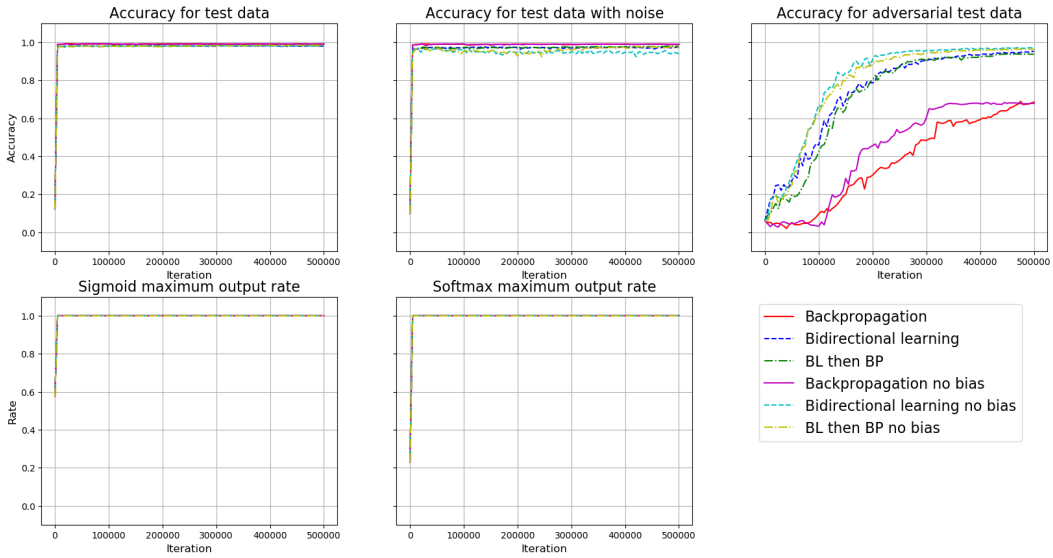

Figure 7: Results of hybrid adversarial network through the iterations of convolutional neural network with two convolutional layers on MNIST dataset.

Table 3: Results of bidirectional propagation of errors on CIFAR-10. Selected iteration with best accuracy test. Bold numbers are the best results for each model.

Model	Learning	Accuracy test	Accuracy noisy	Accuracy adversarial	Sigmoid rate	Softmax rate
Fully connected	BP	**0.3825**	**0.3783**	0.1845	**0.9999**	**0.9954**
no hidden	BL then BP	0.3591	0.3449	0.1807	1	0.9994
layer	BL	0.3332	0.3242	**0.2872**	1	0.996
Fully connected	BP	**0.3769**	**0.373**	0.1853	0.9999	0.996
no hidden	BL then BP	0.374	0.3678	0.1882	**0**	**0.9725**
layer & no bias	BL	0.3211	0.3203	**0.2711**	**0**	0.9999
Fully connected	BP	**0.4009**	**0.3991**	0.2849	0.9497	0.76
one hidden	BL then BP	0.3749	0.3679	0.3006	0.997	0.6082
layer	BL	0.3625	0.36	**0.3054**	**0.9421**	**0.5324**
Fully connected	BP	**0.3929**	**0.3853**	0.2817	**0.9244**	0.6436
one hidden	BL then BP	0.3648	0.3611	**0.2853**	0.9999	0.6956
layer & no bias	BL	0.3508	0.3463	0.2752	0.9984	**0.4298**
Fully connected	BP	**0.3889**	**0.385**	0.2788	0.9851	0.8391
two hidden	BL then BP	0.3836	0.3801	**0.3307**	0.9798	**0.7568**
layers	BL	0.3607	0.3593	0.3199	**0.9528**	0.7628
Fully connected	BP	0.3781	0.3753	0.2492	0.9462	0.7211
two hidden	BL then BP	**0.3872**	**0.3797**	**0.3297**	0.9194	0.7511
layers & no bias	BL	0.3715	0.3658	0.3138	**0.9062**	**0.6578**
Fully connected	BP	0.4204	0.4159	0.3483	0.9699	0.7539
four hidden	BL then BP	**0.4383**	**0.4272**	0.3561	**0.9572**	**0.7404**
layers	BL	0.4337	0.4233	**0.3716**	0.9715	0.8049
Fully connected	BP	0.4208	0.4137	0.351	**0.9791**	0.8627
four hidden	BL then BP	**0.4433**	**0.4334**	**0.3658**	0.9911	0.8359
layers & no bias	BL	0.4314	0.4283	0.3596	0.9807	**0.8289**
CNN	BP	**0.5916**	**0.5848**	0.1837	**0.9952**	0.9861
three conv.	BL then BP	0.57	0.5641	0.1882	0.9984	0.9906
layers	BL	0.5763	0.5651	**0.1927**	0.9978	**0.9794**
CNN	BP	**0.5972**	**0.5932**	0.1715	0.9955	0.9764
three conv.	BL then BP	0.5642	0.562	**0.1909**	**0.9449**	**0.8887**
layers & no bias	BL	0.5676	0.5646	0.1868	0.9797	0.9691

Table 4: Results of Hybrid Adversarial Networks on CIFAR-10. Selected iteration with best accuracy test. Bold numbers are the best results for each model.

Model	Learning	Accuracy test	Accuracy noisy	Accuracy adversarial	Sigmoid rate	Softmax rate
Fully connected one hidden layer	BP	**0.5226**	**0.519**	**0.1734**	0.9996	**0.9914**
	BL then BP	0.4826	0.4758	0.1499	**0.9994**	0.9982
	BL	0.4844	0.4783	0.1534	0.9996	0.9982
Fully connected one hidden layer & no bias	BP	**0.5187**	**0.5162**	**0.1766**	**0.9948**	**0.9429**
	BL then BP	0.4663	0.4509	0.1482	1	0.9999
	BL	0.4565	0.433	0.1536	1	1
CNN two conv. layers	BP	**0.7101**	**0.6973**	0.161	1	1
	BL then BP	0.574	0.5645	**0.258**	1	1
	BL	0.565	0.5429	0.2445	1	1
CNN two conv. layers & no bias	BP	**0.7134**	**0.7067**	0.1733	1	1
	BL then BP	0.5419	0.531	**0.3366**	1	1
	BL	0.4264	0.4114	0.1981	**3.61E-07**	**0.9014**

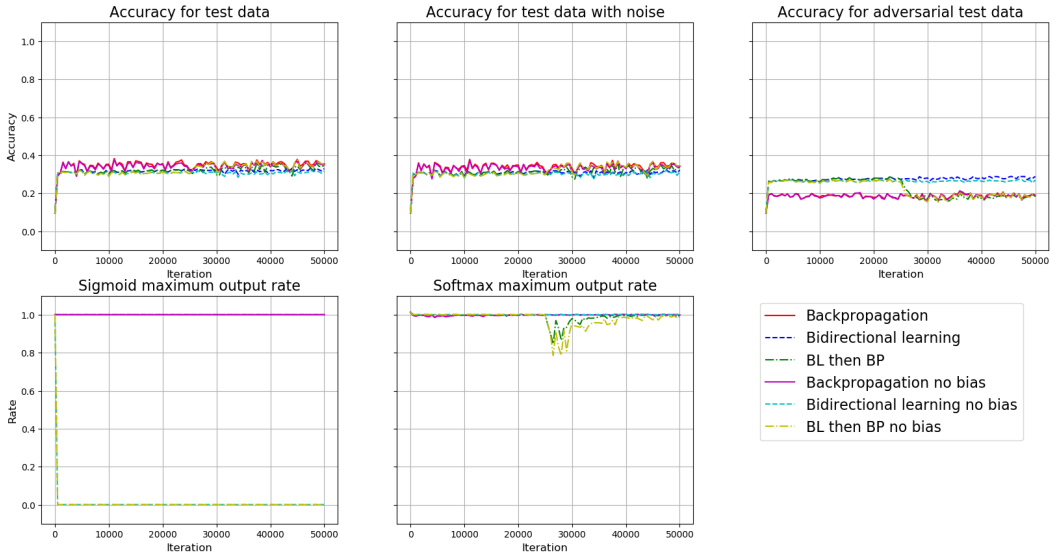

Figure 8: Results of bidirectional propagation of errors through the iterations of fully connected neural network without hidden layer on CIFAR-10 dataset.

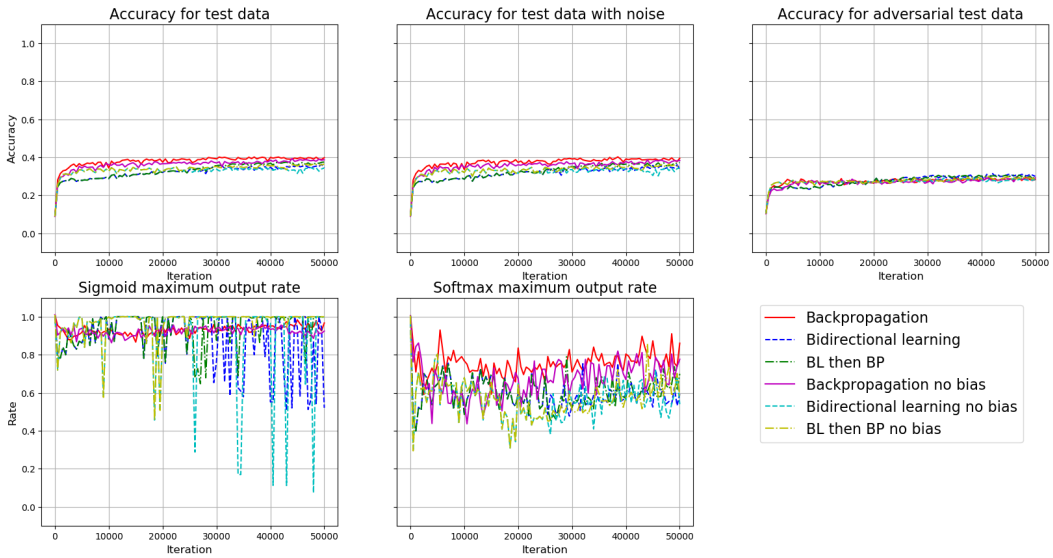

Figure 9: Results of bidirectional propagation of errors through the iterations of fully connected neural network with one hidden layer on CIFAR-10 dataset.

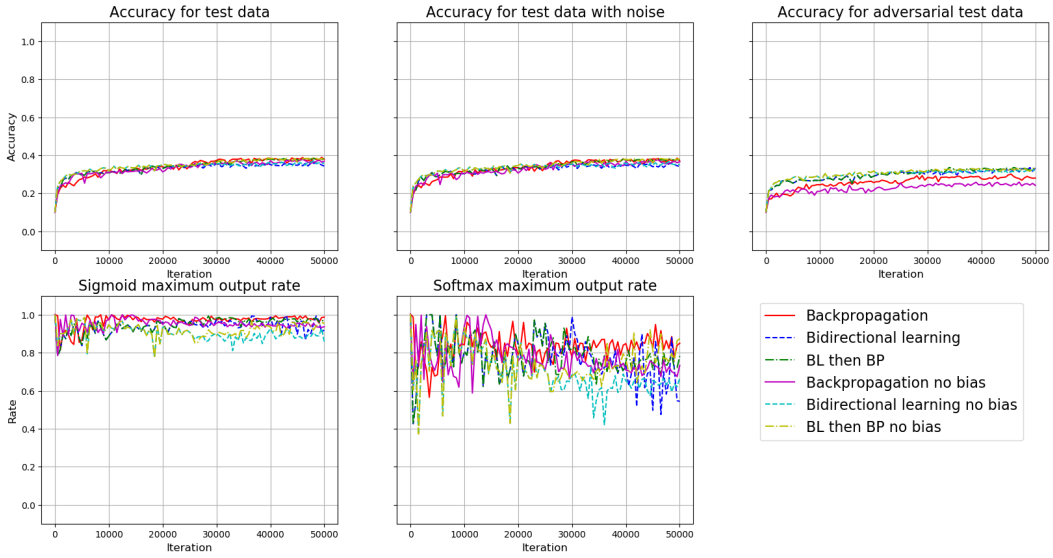

Figure 10: Results of bidirectional propagation of errors through the iterations of fully connected neural network with two hidden layers on CIFAR-10 dataset.

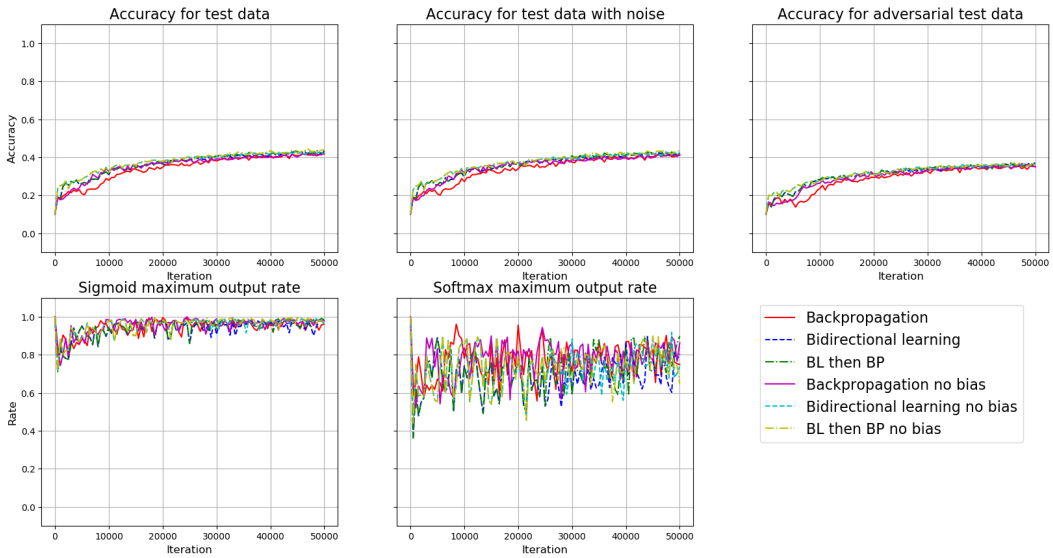

Figure 11: Results of bidirectional propagation of errors through the iterations of fully connected neural network with four hidden layers on CIFAR-10 dataset.

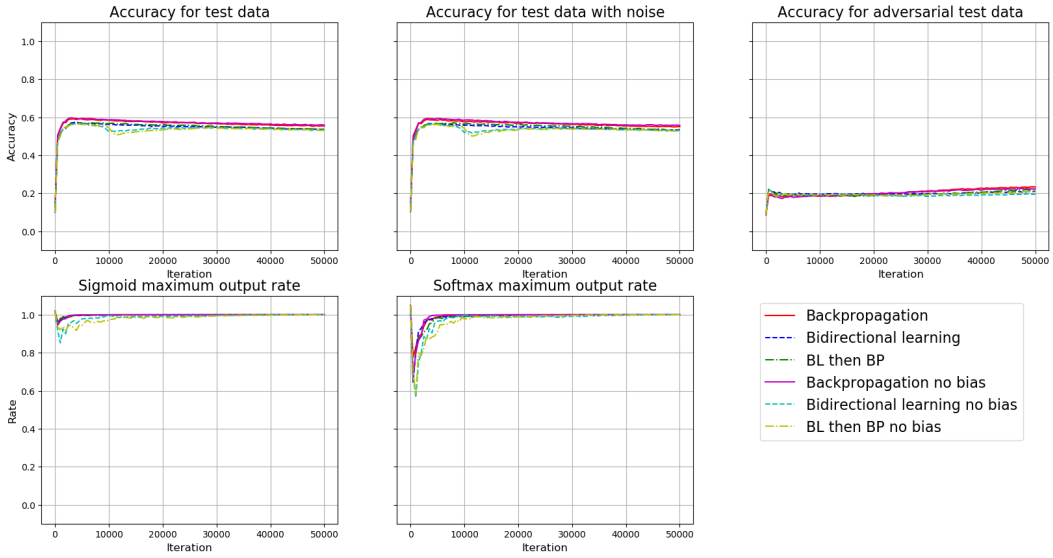

Figure 12: Results of bidirectional propagation of errors through the iterations of convolutional neural network with three convolutional layers on CIFAR-10 dataset.

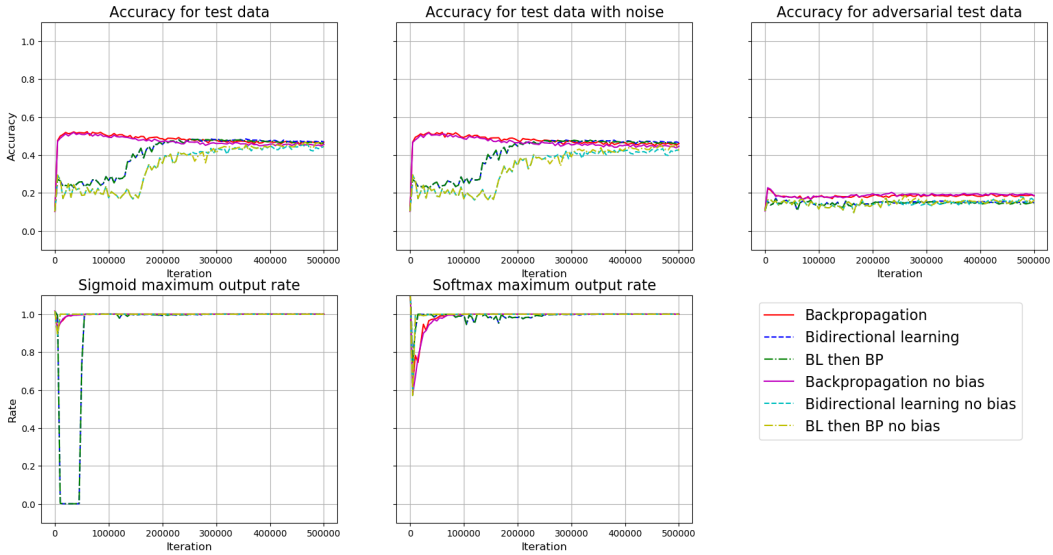

Figure 13: Results of hybrid adversarial network through the iterations of fully connected neural network with one hidden layer on CIFAR-10 dataset.

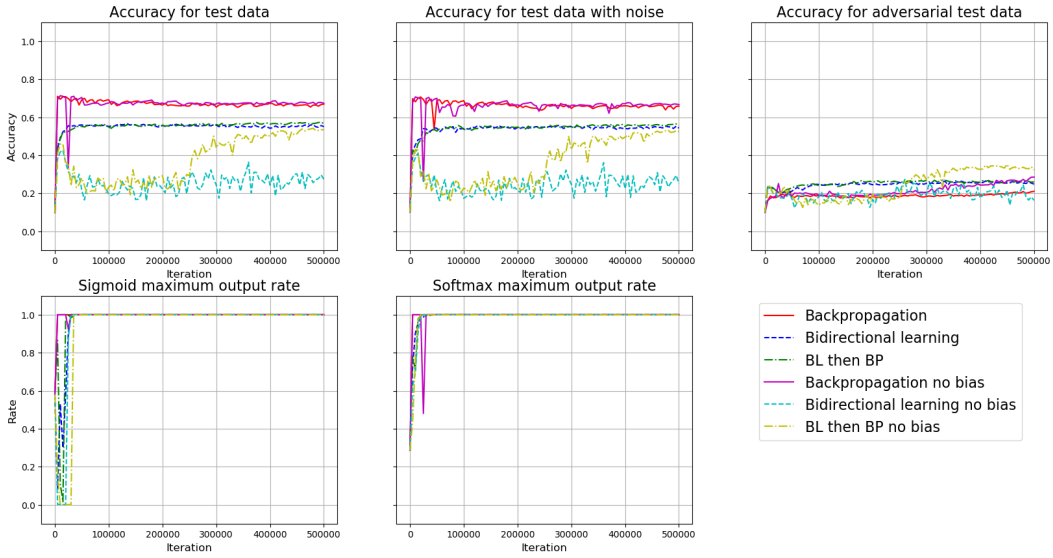

Figure 14: Results of hybrid adversarial network through the iterations of convolutional neural network with two convolutional layers on CIFAR-10 dataset.