Appendices on Frequency Regularization

Paper ID: 1077

FREQUENCY REGULARIZATION

The proposed frequency regularization can dropped from 90% to 99.99% of parameters in various network architecture. Due to the page limitation of the main paper, we only proposed the total number of parameters in networks. In this section, the details of parameters number on every layer are demonstrated in Table 1 2 3 4 5 6 7 8 9 10 11 12 13 14. It should be noted that we did not consider the bias in the convolution layers, fully connected layers and transposed convolution layers during our evaluation, since the bias only represents a small portion of network parameters and most of the previous researchers also ignored them. Similarly, the parameters in batchnorm layers are also ignored with the same reason. Since the UNet pre-trained model is included in the supplementary materials, we, therefore, didn't present the details of UNet.

Table 1: Details of non-zero parameters numbers in AlexNet-v1.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	23,232	233	1.0029%(100×)
Conv2d	307,200	3,074	1.0007%(100×)
Conv2d	663,552	6,637	1.0002%(100×)
Conv2d	884,736	8,848	1.0001%(100×)
Conv2d	589,824	5,899	1.0001%(100×)
Linear	37,748,736	377,489	1.0000%(100×)
Linear	16,777,216	167,774	1.0000%(100×)
Linear	40,960	411	1.0034%(100×)
total	57,035,456	570,365	1.0000%(100×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 2: Details of non-zero parameters numbers in AlexNet-v2.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	23,232	128	0.5510%(182×)
Conv2d	307,200	308	0.1003%(998×)
Conv2d	663,552	665	0.1002%(998×)
Conv2d	884,736	886	0.1001%(999×)
Conv2d	589,824	591	0.1002%(999×)
Linear	37,748,736	37,751	0.1000%(1000×)
Linear	16,777,216	16,779	0.1000%(1000×)
Linear	40,960	256	0.6250%(161×)
total	57,035,456	57,364	0.1006%(995×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 3: Details of non-zero parameters numbers in AlexNet-v3.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	23,232	128	0.5510%(182×)
Conv2d	307,200	128	0.0417%(2401×)
Conv2d	663,552	128	0.0193%(5185×)
Conv2d	884,736	128	0.0145%(6913×)
Conv2d	589,824	128	0.0217%(4609×)
Linear	37,748,736	256	0.0007%(147457×)
Linear	16,777,216	256	0.0015%(65537×)
Linear	40,960	256	0.6250%(161×)
total	57,035,456	1,408	0.0025%(40509×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 4: Details of non-zero parameters numbers in AlexNet-v4.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	23,232	128	0.5510%(182×)
Conv2d	307,200	128	0.0417%(2401×)
Conv2d	663,552	128	0.0193%(5185×)
Conv2d	884,736	128	0.0145%(6913×)
Conv2d	589,824	128	0.0217%(4609×)
Linear	37,748,736	256	0.0007%(147457×)
Linear	16,777,216	256	0.0015%(65537×)
Linear	40,960	256	0.6250%(161×)
total	57,035,456	1,408(float16)	0.00125%(81018×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 5: Details of non-zero parameters numbers in VGG16-v1.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	1,728	128	7.4074%(14×)
Conv2d	36,864	370	1.0037%(100×)
Conv2d	73,728	738	1.0010%(100×)
Conv2d	147,456	1,476	1.0010%(100×)
Conv2d	294,912	2,950	1.0003%(100×)
Conv2d	589,824	5,899	1.0001%(100×)
Conv2d	589,824	5,899	1.0001%(100×)
Conv2d	589,824	5,899	1.0001%(100×)
Conv2d	1,179,648	11,798	1.0001%(100×)
Conv2d	2,359,296	23,595	1.0001%(100×)
Conv2d	2,359,296	23,595	1.0001%(100×)
Conv2d	2,359,296	23,595	1.0001%(100×)
Conv2d	2,359,296	23,595	1.0001%(100×)
Conv2d	2,359,296	23,595	1.0001%(100×)
Conv2d	2,359,296	23,595	1.0001%(100×)
Conv2d	2,359,296	23,595	1.0001%(100×)
Linear	5,120	256	5.0000%(21×)
total	20,024,000	200,578	1.0017%(100×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 7: Details of non-zero parameters numbers in VGG16-v3.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	1,728	128	7.4074%(14×)
Conv2d	36,864	128	0.3472%(289×)
Conv2d	73,728	128	0.1736%(577×)
Conv2d	147,456	128	0.0868%(1153×)
Conv2d	294,912	128	0.0434%(2305×)
Conv2d	589,824	128	0.0217%(4609×)
Conv2d	589,824	128	0.0217%(4609×)
Conv2d	589,824	128	0.0217%(4609×)
Conv2d	1,179,648	128	0.0109%(9217×)
Conv2d	2,359,296	128	0.0054%(18433×)
Conv2d	2,359,296	128	0.0054%(18433×)
Conv2d	2,359,296	128	0.0054%(18433×)
Conv2d	2,359,296	128	0.0054%(18433×)
Conv2d	2,359,296	128	0.0054%(18433×)
Conv2d	2,359,296	128	0.0054%(18433×)
Conv2d	2,359,296	128	0.0054%(18433×)
total	20,018,880	2,048	0.0102%(9775×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 6: Details of non-zero parameters numbers in VGG16-v2.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	1,728	128	7.4074%(14×)
Conv2d	36,864	128	0.3472%(289×)
Conv2d	73,728	128	0.1736%(577×)
Conv2d	147,456	148	0.1004%(997×)
Conv2d	294,912	296	0.1004%(997×)
Conv2d	589,824	591	0.1002%(999×)
Conv2d	589,824	591	0.1002%(999×)
Conv2d	589,824	591	0.1002%(999×)
Conv2d	1,179,648	1,181	0.1001%(999×)
Conv2d	2,359,296	2,360	0.1000%(1000×)
Conv2d	2,359,296	2,360	0.1000%(1000×)
Conv2d	2,359,296	2,360	0.1000%(1000×)
Conv2d	2,359,296	2,360	0.1000%(1000×)
Conv2d	2,359,296	2,360	0.1000%(1000×)
Conv2d	2,359,296	2,360	0.1000%(1000×)
Conv2d	2,359,296	2,360	0.1000%(1000×)
total	20,018,880	20,302	0.1014%(987×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 8: Details of non-zero parameters numbers in ResNet-v1.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	36,864	370	1.0037%(100×)
Conv2d	36,864	370	1.0037%(100×)
Conv2d	36,864	370	1.0037%(100×)
Conv2d	36,864	370	1.0037%(100×)
Conv2d	73,728	738	1.0010%(100×)
Conv2d	147,456	1,476	1.0010%(100×)
Conv2d	8,192	128	1.5625%(65×)
Conv2d	147,456	1,476	1.0010%(100×)
Conv2d	147,456	1,476	1.0010%(100×)
Conv2d	294,912	2,950	1.0003%(100×)
Conv2d	589,824	5,899	1.0001%(100×)
Conv2d	32,768	329	1.0040%(100×)
Conv2d	589,824	5,899	1.0001%(100×)
Conv2d	589,824	5,899	1.0001%(100×)
Conv2d	1,179,648	11,798	1.0001%(100×)
Conv2d	2,359,296	23,595	1.0001%(100×)
Conv2d	131,072	1,312	1.0010%(100×)
Conv2d	2,359,296	23,595	1.0001%(100×)
Conv2d	2,359,296	23,595	1.0001%(100×)
Linear	5,120	256	5.0000%(21×)
total	11,162,624	111,901	1.0025%(100×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 9: Details of non-zero parameters numbers in ResNet-v2.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	36,864	128	0.3472%(289×)
Conv2d	36,864	128	0.3472%(289×)
Conv2d	36,864	128	0.3472%(289×)
Conv2d	36,864	128	0.3472%(289×)
Conv2d	73,728	128	0.1736%(577×)
Conv2d	147,456	148	0.1004%(997×)
Conv2d	8,192	128	1.5625%(65×)
Conv2d	147,456	148	0.1004%(997×)
Conv2d	147,456	148	0.1004%(997×)
Conv2d	294,912	296	0.1004%(997×)
Conv2d	589,824	591	0.1002%(999×)
Conv2d	32,768	128	0.3906%(257×)
Conv2d	589,824	591	0.1002%(999×)
Conv2d	589,824	591	0.1002%(999×)
Conv2d	1,179,648	1,181	0.1001%(999×)
Conv2d	2,359,296	2,360	0.1000%(1000×)
Conv2d	131,072	132	0.1007%(993×)
Conv2d	2,359,296	2,360	0.1000%(1000×)
Conv2d	2,359,296	2,360	0.1000%(1000×)
Linear	5,120	256	5.0000%(21×)
total	11,162,624	12,058	0.1080%(926×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 10: Details of non-zero parameters numbers in ResNet-v3.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	36,864	128	0.3472%(289×)
Conv2d	36,864	128	0.3472%(289×)
Conv2d	36,864	128	0.3472%(289×)
Conv2d	36,864	128	0.3472%(289×)
Conv2d	73,728	128	0.1736%(577×)
Conv2d	147,456	128	0.0868%(1153×)
Conv2d	8,192	128	1.5625%(65×)
Conv2d	147,456	128	0.0868%(1153×)
Conv2d	147,456	128	0.0868%(1153×)
Conv2d	294,912	128	0.0434%(2305×)
Conv2d	589,824	128	0.0217%(4609×)
Conv2d	32,768	128	0.3906%(257×)
Conv2d	589,824	128	0.0217%(4609×)
Conv2d	589,824	128	0.0217%(4609×)
Conv2d	1,179,648	128	0.0109%(9217×)
Conv2d	2,359,296	128	0.0054%(18433×)
Conv2d	131,072	128	0.0977%(1025×)
Conv2d	2,359,296	128	0.0054%(18433×)
Conv2d	2,359,296	128	0.0054%(18433×)
Linear	5,120	256	5.0000%(21×)
total	11,162,624	2,688	0.0241%(4153×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 11: Details of non-zero parameters numbers in ViT-v1.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Linear	33,280	33,280	100.0000%(2×)
Linear	33,280	24,576	100.0000%(2×)
Linear	786,432	65,520	8.3313%(13×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	786,432	65,520	8.3313%(13×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	786,432	65,520	8.3313%(13×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	786,432	65,520	8.3313%(13×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	786,432	65,520	8.3313%(13×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	786,432	65,520	8.3313%(13×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	262,144	26,215	10.0002%(10×)
Linear	512	512	100.0000%(2×)
Linear	5,120	5,120	100.0000%(2×)
total	9,500,672	928,478	9.7727%(11×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 12: Details of non-zero parameters numbers in ViT-v2.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Linear	33,280	33,280	100.0000%(2×)
Linear	33,280	24,576	100.0000%(2×)
Linear	786,432	7,865	1.0001%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	786,432	7,865	1.0001%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	786,432	7,865	1.0001%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	786,432	7,865	1.0001%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	786,432	7,865	1.0001%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	786,432	7,865	1.0001%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	262,144	2,622	1.0002%(100×)
Linear	512	512	100.0000%(2×)
Linear	5,120	5,120	100.0000%(2×)
total	9,500,672	157,874	1.6617%(61×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 13: Details of non-zero parameters numbers in the Discriminator of GAN-v1.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
Conv2d	1,024	128	12.5000%(9×)
Conv2d	131,072	1,312	1.0010%(100×)
Conv2d	524,288	5,244	1.0002%(100×)
Conv2d	2,097,152	20,973	1.0001%(100×)
Conv2d	8,192	128	1.5625%(65×)
total	2,761,728	27,785	1.0061%(100×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters

Table 14: Details of non-zero parameters numbers in the Generator of GAN-v1.

Layer Type	Org. NoP.	Rem. NoP.	Compress Rate
ConvTranspose2d	819,200	8,192	1.0000%(101×)
ConvTranspose2d	2,097,152	20,972	1.0000%(100×)
ConvTranspose2d	524,288	5,243	1.0000%(100×)
ConvTranspose2d	131,072	1,311	1.0002%(100×)
ConvTranspose2d	1,024	32	3.1250%(33×)
total	3,572,736	35,750	1.0006%(100×)

Org. NoP.: Original number of parameters. Rem. NoP. Remaining number of parameters