Supplementary Material
Understanding the Dynamics of DNNs Using Graph Modularity

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This document supplements our paper by providing additional experiments and experimental details.

A Supplementary Experiments

A.1 Different Similarity indexes to Calculate the Similarity Matrix

In this subsection, we replace cosine similarity with pearson correlation coefficient to calculate the similarity matrix. We can observe from Fig. B1 that the modularity curves are almost the same as those in the manuscript, demonstrating that various similarity indexes can be utilized to obtain the modularity.

A.2 Modularity curves of Randomly Initialized Models

Having observed the upward trend of modularity emerging in pre-trained models, we next study whether this phenomenon exists in randomly initialized models. Hence, we conduct experiments with VGG16 and ResNet18 on CIFAR-10. In Fig. B2, we show the modularity curves of randomly initialized models. Since the randomly initialized models can not learn useful feature representations, the connections among samples at each layer are completely random. Thus, the modularity nearly maintains constant in the randomly initialized models compared to pre-trained models.

A.3 Ablation of k

In Fig.7(b), the variability of k is small, it is reasonable to question whether k has a significant impact when k is large ($k >> 11$). To answer this doubt, we set $N = 500$, $k = 100, 200, 300, 400$ to repeat the experiment. Fig. B3 shows the result, from which we find that different values of k have a certain impact on modularity values but do not hurt the tendency of modularity curves. When k is large, each node connects many unrelated nodes (i.e., nodes belonging to different communities), which weakens the intra-community connections but strengthens the inter-community connections, resulting in a decrease in the modularity value.

B Implementation Details

B.1 ImageNet50

The 50 classes we randomly selected from ImageNet [49] are shown as follows, you can also build the dataset yourself.

n01443537 goldfish, Carassius auratus

n01484850 great white shark, white shark, man-eater, man-eating shark, Carcharodon carcharias

n01491361 tiger shark, Galeocerdo cuvieri

n01494475 hammerhead, hammerhead shark

n01496331 electric ray, crampfish, numbfish, torpedo

n01498041 stingray

n01514668 cock

n01514859 hen

n01518878 ostrich, Struthio camelus

n01530575 brambling, Fringilla montifringilla

n01531178 goldfinch, Carduelis carduelis

n01532829 house finch, linnet, Carpodacus mexicanus

n01534433 junco, snowbird

n01537544 indigo bunting, indigo finch, indigo bird, Passerina cyanea

n01558993 robin, American robin, Turdus migratorius

n01560419 bulbul

n01580077 jay

n01582220 magpie

n01592084 chickadee

n01601694 water ouzel, dipper

n01608432 kite

n01614925 bald eagle, American eagle, Haliaeetus leucocephalus

n01616318 vulture

n01632777 axolotl, mud puppy, Ambystoma mexicanum

n01667778 terrapin

n01688243 frilled lizard, Chlamydosaurus kingi

n01728920 ringneck snake, ring-necked snake, ring snake

n01773157 black and gold garden spider, Argiope aurantia

n01795545 black grouse

n01847000 drake

n07768694 pomegranate

n07802026 hay
n07831146 carbonara
n07836838 chocolate sauce, chocolate syrup
n07860988 dough
n07871810 meat loaf, meatloaf
n07873807 pizza, pizza pie
n09193705 alp
n09229709 bubble
n09246464 cliff, drop, drop-off
n09256479 coral reef
n09288635 geyser
n09332890 lakeside, lakeshore
n09399592 promontory, headland, head, foreland
n09421951 sandbar, sand bar
n09428293 seashore, coast, seacoast, sea-coast
n09468604 valley, vale
n09472597 volcano
n09835506 ballplayer, baseball player
n10148035 groom, bridegroom

B.2 Statistics of Models

The statistics of pre-trained models used in this paper are shown in Table B1. Moreover, in order to better investigate the redundant layers in models. We design a series of variants. The model structures of these variants are shown in Table B2-B5.

Table B1. The statistics of pre-trained models.

Dataset	VGGs				ResNets				
	V11	V13	V16	V19	R18	R34	R50	R101	R152
CIFAR-10	92.11%	93.68%	93.63%	93.36%	94.78%	95.14%	95.38%	95.18%	95.32%
CIFAR-100	66.87%	70.19%	72.34%	72.63%	76.87%	76.69%	78.03%	78.21%	78.64%
ImageNet50	83.97%	85.87%	85.04%	87.32%	82.55%	82.99%	85.04%	87.32%	87.89%

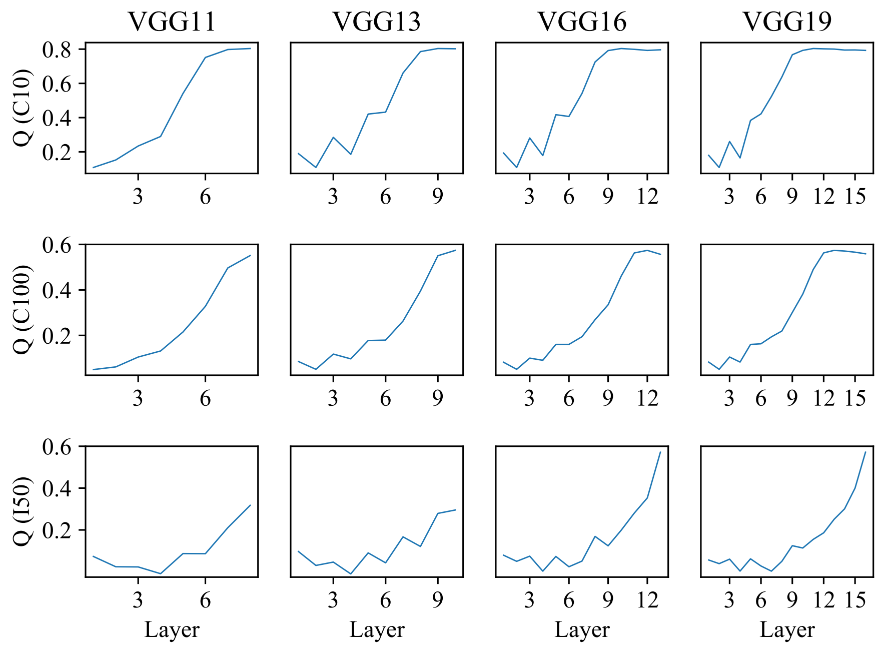

Fig. B1. We utilize pearson correlation coefficient instead of cosine similarity to calculate the similarity matrix. We can find the modularity curves are almost same as those in the main text, which demonstrates that our modularity can be obtained by various indexes.

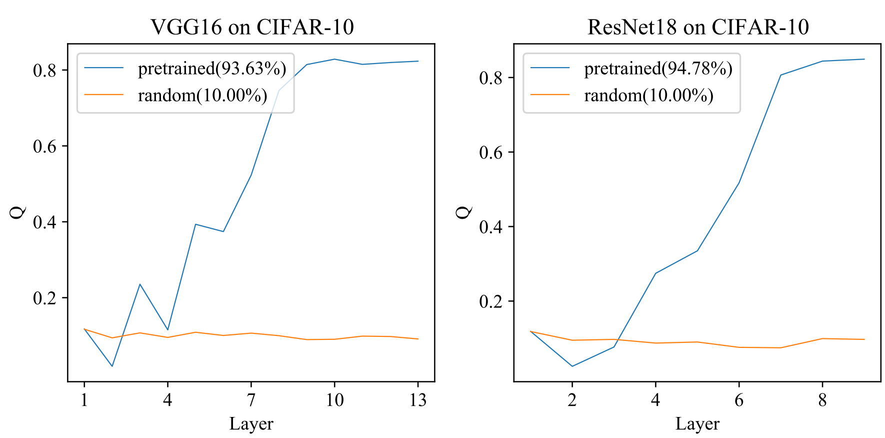

Fig. B2. Modularity curves of well-optimized and randomly initialized models.

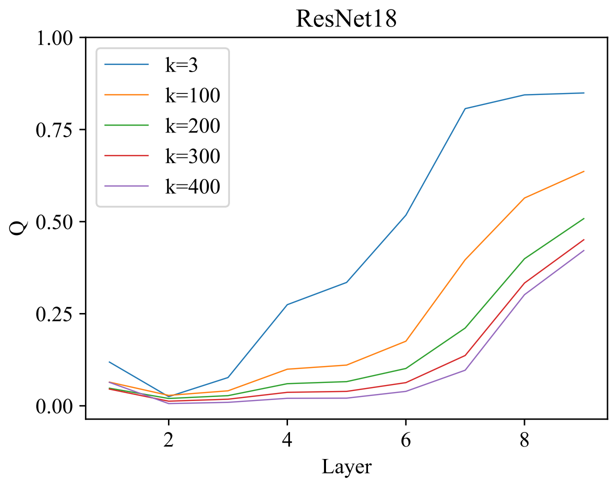

Fig. B3. The influence of k on the modularity when k is large.

Table B2. The model structures of variants of VGG19 on CIFAR-10.

<table>
<tr><td>VGG19_6</td><td>VGG19_5</td><td>VGG19_4</td><td>VGG19_3</td><td>VGG19_2</td><td>VGG19_1</td><td>VGG19</td></tr>
<tr><td colspan="7">input (32 × 32 RGB images)</td></tr>
<tr><td>conv3-64
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<tr><td colspan="7">maxpool</td></tr>
<tr><td>conv3-128
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<tr><td colspan="7">maxpool</td></tr>
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<tr><td colspan="7">maxpool</td></tr>
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<tr><td colspan="7">maxpool</td></tr>
<tr><td>conv3-512</td><td>conv3-512</td><td>conv3-512</td><td>conv3-512</td><td>conv3-512
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<tr><td colspan="7">maxpool</td></tr>
<tr><td colspan="7">FC-512</td></tr>
<tr><td colspan="7">FC-512</td></tr>
<tr><td colspan="7">FC-10</td></tr>
<tr><td colspan="7">soft-max</td></tr>
</table>

Table B3. The model structures of variants of ResNet152 on CIFAR-10.

Layer	Size	Res152_30		Res152_26		Res152_21		Res152_16		Res152_11		Res152_5	
conv1	32×32	3×3, 64, stride 1											
conv2_x	32×32	1×1, 64 3×3, 64 1×1, 256	3	1×1, 64 3×3, 64 1×1, 256	3	1×1, 64 3×3, 64 1×1, 256	3	1×1, 64 3×3, 64 1×1, 256	3	1×1, 64 3×3, 64 1×1, 256	3	1×1, 64 3×3, 64 1×1, 256	3
conv3_x	16×16	1×1, 128 3×3, 128 1×1, 512	8	1×1, 128 3×3, 128 1×1, 512	8	1×1, 128 3×3, 128 1×1, 512	8	1×1, 128 3×3, 128 1×1, 512	8	1×1, 128 3×3, 128 1×1, 512	8	1×1, 128 3×3, 128 1×1, 512	8
conv4_x	8×8	1×1, 256 3×3, 256 1×1, 1024	6	1×1, 256 3×3, 256 1×1, 1024	10	1×1, 256 3×3, 256 1×1, 1024	15	1×1, 256 3×3, 256 1×1, 1024	20	1×1, 256 3×3, 256 1×1, 1024	25	1×1, 256 3×3, 256 1×1, 1024	31
conv5_x	4×4	1×1, 512 3×3, 512 1×1, 2048	3	1×1, 512 3×3, 512 1×1, 2048	3	1×1, 512 3×3, 512 1×1, 2048	3	1×1, 512 3×3, 512 1×1, 2048	3	1×1, 512 3×3, 512 1×1, 2048	3	1×1, 512 3×3, 512 1×1, 2048	3
	1×1	adaptive average pool, 10-d fc, softmax											

Table B4. The model structures of variants of ResNet152 on ImageNet50.

Layer	Size	Res152_30		Res152_26		Res152_21		Res152_16		Res152_11		Res152_5	
conv1	112×112	7×7, 64, stride 2											
conv2_x	56×56	3×3 max pool, stride 2											
		1×1, 64 3×3, 64 1×1, 256	3	1×1, 64 3×3, 64 1×1, 256	3	1×1, 64 3×3, 64 1×1, 256	3	1×1, 64 3×3, 64 1×1, 256	3	1×1, 64 3×3, 64 1×1, 256	3	1×1, 64 3×3, 64 1×1, 256	3
conv3_x	28×28	1×1, 128 3×3, 128 1×1, 512	8	1×1, 128 3×3, 128 1×1, 512	8	1×1, 128 3×3, 128 1×1, 512	8	1×1, 128 3×3, 128 1×1, 512	8	1×1, 128 3×3, 128 1×1, 512	8	1×1, 128 3×3, 128 1×1, 512	8
conv4_x	14×14	1×1, 256 3×3, 256 1×1, 1024	6	1×1, 256 3×3, 256 1×1, 1024	10	1×1, 256 3×3, 256 1×1, 1024	15	1×1, 256 3×3, 256 1×1, 1024	20	1×1, 256 3×3, 256 1×1, 1024	25	1×1, 256 3×3, 256 1×1, 1024	31
conv5_x	7×7	1×1, 512 3×3, 512 1×1, 2048	3	1×1, 512 3×3, 512 1×1, 2048	3	1×1, 512 3×3, 512 1×1, 2048	3	1×1, 512 3×3, 512 1×1, 2048	3	1×1, 512 3×3, 512 1×1, 2048	3	1×1, 512 3×3, 512 1×1, 2048	3
	1×1	adaptive average pool, 50-d fc, softmax											

Table B5. The model structures of variants of VGG11 on CIFAR-10 and CIFAR-100.

<table>
<tr><th>VGG11_3</th><th>VGG11_2</th><th>VGG11_1</th><th>VGG11</th></tr>
<tr><td colspan="4">input (32 × 32 RGB images)</td></tr>
<tr><td>conv3-64</td><td>conv3-64</td><td>conv3-64</td><td>conv3-64</td></tr>
<tr><td colspan="4">maxpool</td></tr>
<tr><td>conv3-128</td><td>conv3-128</td><td>conv3-128</td><td>conv3-128</td></tr>
<tr><td colspan="4">maxpool</td></tr>
<tr><td>conv3-256</td><td>conv3-256
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conv3-256</td></tr>
<tr><td colspan="4">maxpool</td></tr>
<tr><td>conv3-512</td><td>conv3-512</td><td>conv3-512
conv3-512</td><td>conv3-512
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<tr><td colspan="4">maxpool</td></tr>
<tr><td>conv3-512</td><td>conv3-512</td><td>conv3-512</td><td>conv3-512
conv3-512</td></tr>
<tr><td colspan="4">maxpool</td></tr>
<tr><td colspan="4">FC-512</td></tr>
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<tr><td colspan="4">FC-10</td></tr>
<tr><td colspan="4">soft-max</td></tr>
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