

Representation	Lowshot phase	n=1	2	5	10	20
<i>ResNet-10</i>						
Baseline	Classifier	2.26	9.70	25.67	35.49	41.87
Baseline	Generation* + Classifier	9.55	16.95	26.78	34.71	41.07
SGM*	Classifier	4.51	13.38	28.35	36.52	41.38
SGM*	Generation* + Classifier	9.60	17.96	28.35	36.52	41.38
Batch SGM*	Classifier	4.62	13.57	27.97	35.96	40.84
L2*	Classifier	5.58	15.53	28.66	34.24	37.21
L1*	Classifier	4.88	14.40	28.54	35.59	39.90
Triplets	Classifier	6.22	15.13	24.58	28.73	31.14
Dropout [3]	Classifier	7.22	16.58	27.77	33.28	36.80
Decov [1]	Classifier	1.75	8.83	26.52	36.33	41.87
Multiverse	Classifier [4]	1.55	6.47	19.93	31.04	39.65
Baseline	Model Regression [6]	5.73	15.62	30.53	38.25	43.57
Baseline	Matching Network [5]	13.31	20.33	29.99	36.19	40.37
Baseline-ft	Classifier	2.26	8.52	23.97	34.42	40.96
<i>ResNet-50</i>						
Baseline	Classifier	4.82	15.22	33.54	42.92	48.95
Baseline	Generation* + Classifier	14.26	22.45	33.48	41.31	48.95
SGM*	Classifier	8.28	18.81	33.96	41.80	46.48
SGM*	Generation* + Classifier	13.57	22.79	33.96	41.80	46.48

Table 1: Top-1 accuracy on novel classes. *Our methods.

1 Numerical results

Tables 1 and 2 show the numerical top-1 accuracy on novel classes and all classes respectively. Note that some methods such as Model Regression [6] and Matching Networks [5] improve the top-1 accuracy for novel classes, but this seems to be at the expense of base classes, resulting in a lower accuracy when measured on all classes taken together.

Standard deviations for the accuracies are shown in Tables 3, 4, 5 and 6. Most of these values are less than 0.5 points.

2 Other experimental details

Tables 7 and 9 show the base and novel categories we use for cross-validation. Tables 8 and 10 show the base and novel categories we use for our final results.

Figure 1 shows the ResNet-10 architecture. The ResNet-50 architecture is as described in [2].

Representation	Lowshot phase	n=1	2	5	10	20
<i>ResNet-10</i>						
Baseline	Classifier	29.12	33.24	41.54	46.81	50.30
Baseline	Generation* + Classifier	33.13	36.99	42.60	47.53	<i>51.81</i>
SGM*	Classifier	32.09	36.98	44.85	49.19	51.89
SGM*	Generation* + Classifier	34.18	38.45	44.85	49.19	51.89
Batch SGM*	Classifier	32.08	37.02	<i>44.50</i>	<i>48.74</i>	51.43
L2*	Classifier	32.40	<i>37.57</i>	44.49	47.64	49.38
L1*	Classifier	30.37	35.40	42.82	46.80	49.39
Triplets	Classifier	28.09	32.16	37.17	39.85	41.47
Dropout [3]	Classifier	31.29	36.05	42.12	45.33	47.53
Decov [1]	Classifier	30.13	34.21	43.61	48.65	51.70
Multiverse [4]	Classifier	30.19	33.11	40.80	46.67	50.92
Baseline	Model Regression [6]	29.70	33.84	38.15	39.23	40.21
Baseline	Matching Network [5]	<i>33.93</i>	37.30	42.70	46.74	49.77
Baseline-ft	Classifier	28.14	31.55	39.61	45.04	48.63
<i>ResNet-50</i>						
Baseline	Classifier	34.28	40.26	<i>50.19</i>	55.09	58.32
Baseline	Generation* + Classifier	<i>38.77</i>	<i>43.21</i>	49.60	54.18	58.32
SGM*	Classifier	36.76	42.50	50.23	<i>54.31</i>	<i>56.84</i>
SGM*	Generation* + Classifier	38.90	43.51	50.23	<i>54.31</i>	<i>56.84</i>

Table 2: Top-1 accuracy on all classes. *Our methods.

Representation	Lowshot phase	n=1	2	5	10	20
<i>ResNet-10</i>						
Baseline	Classifier	0.33	0.47	0.45	0.36	0.23
Baseline	Generation* + Classifier	0.31	0.41	0.54	0.41	0.28
SGM*	Classifier	0.57	0.26	0.21	0.39	0.35
SGM*	Generation* + Classifier	0.48	0.42	0.21	0.39	0.35
Batch SGM*	Classifier	0.62	0.35	0.32	0.43	0.38
L2*	Classifier	0.79	0.42	0.49	0.38	0.26
L1*	Classifier	0.18	0.48	0.26	0.58	0.34
Triplets	Classifier	0.58	0.68	0.30	0.60	0.34
Dropout [3]	Classifier	0.72	0.47	0.31	0.44	0.32
Decov [1]	Classifier	0.51	0.21	0.30	0.68	0.38
Multiverse [4]	Classifier	0.42	0.43	0.29	0.55	0.36
Baseline	Model Regression [6]	0.29	0.43	0.38	0.49	0.17
Baseline	Matching Network [5]	0.50	0.64	0.17	0.50	0.31
Baseline-ft	Classifier	0.53	0.63	0.17	0.40	0.28
<i>ResNet-50</i>						
Baseline	Classifier	0.52	0.33	0.21	0.34	0.34
Baseline	Generation* + Classifier	0.80	0.34	0.42	0.44	0.34
SGM*	Classifier	0.66	0.78	0.24	0.38	0.19
SGM*	Generation* + Classifier	1.09	0.28	0.32	0.34	0.43

Table 3: Standard deviation: top-5 accuracy, novel classes. *Our methods.

Representation	Lowshot phase	n=1	2	5	10	20
<i>ResNet-10</i>						
Baseline	Classifier	0.23	0.31	0.27	0.26	0.14
Baseline	Generation* + Classifier	0.23	0.32	0.36	0.26	0.14
SGM*	Classifier	0.35	0.19	0.18	0.24	0.23
SGM*	Generation* + Classifier	0.29	0.26	0.18	0.24	0.23
Batch SGM*	Classifier	0.38	0.20	0.18	0.25	0.25
L1*	Classifier	0.11	0.32	0.19	0.35	0.20
L2*	Classifier	0.49	0.26	0.25	0.21	0.14
Triplets	Classifier	0.36	0.40	0.22	0.37	0.21
Dropout [3]	Classifier	0.45	0.34	0.20	0.28	0.17
Decov [1]	Classifier	0.29	0.16	0.20	0.42	0.24
Multiverse [4]	Classifier	0.24	0.27	0.15	0.34	0.28
Baseline	Model Regression [6]	0.19	0.30	0.25	0.29	0.14
Baseline	Matching Network [5]	0.33	0.49	0.10	0.32	0.20
Baseline-ft	Classifier	0.34	0.43	0.14	0.23	0.21
<i>ResNet-50</i>						
Baseline	Classifier	0.32	0.21	0.10	0.21	0.22
Baseline	Generation* + Classifier	0.49	0.22	0.27	0.25	0.22
SGM*	Classifier	0.41	0.43	0.12	0.22	0.11
SGM*	Generation* + Classifier	0.67	0.14	0.22	0.21	0.30

Table 4: Standard deviation: top-5 accuracy, all classes. *Our methods.

Representation	Lowshot phase	n=1	2	5	10	20
<i>ResNet-10</i>						
Baseline	Classifier	0.21	0.39	0.76	0.53	0.42
Baseline	Generation* + Classifier	0.32	0.36	0.70	0.42	0.43
SGM*	Classifier	0.32	0.37	0.52	0.27	0.44
SGM*	Generation* + Classifier	0.32	0.63	0.52	0.27	0.44
Batch SGM*	Classifier	0.32	0.61	0.41	0.53	0.62
L2*	Classifier	0.36	0.44	0.59	0.41	0.42
L1*	Classifier	0.23	0.46	0.51	0.59	0.25
Triplets	Classifier	0.13	0.37	0.54	0.32	0.38
Dropout [3]	Classifier	0.24	0.61	0.84	0.52	0.42
Decov [1]	Classifier	0.09	0.24	0.30	0.38	0.37
Multiverse [4]	Classifier	0.17	0.19	0.56	0.59	0.29
Baseline	Model Regression [6]	0.15	0.41	0.52	0.38	0.39
Baseline	Matching Netowrk [5]	0.63	0.68	0.67	0.52	0.35
Baseline-ft	Classifier	0.23	0.29	0.68	0.35	0.43
<i>ResNet-50</i>						
Baseline	Classifier	0.18	0.28	0.36	0.64	0.63
Baseline	Generation* + Classifier	0.28	0.32	0.47	0.64	0.63
SGM*	Classifier	0.38	0.41	0.38	0.55	0.45
SGM*	Generation* + Classifier	0.58	0.61	0.55	0.74	0.49

Table 5: Standard deviation: top-1 accuracy, novel classes. *Our methods.

Representation	Lowshot phase	n=1	2	5	10	20
<i>ResNet-10</i>						
Baseline	Classifier	0.13	0.28	0.48	0.36	0.28
Baseline	Generation* + Classifier	0.16	0.24	0.43	0.25	0.24
SGM*	Classifier	0.19	0.22	0.25	0.15	0.32
SGM*	Generation* + Classifier	0.14	0.34	0.25	0.15	0.32
Batch SGM*	Classifier	0.17	0.39	0.25	0.31	0.38
L2*	Classifier	0.23	0.29	0.37	0.27	0.29
L1*	Classifier	0.11	0.31	0.24	0.33	0.13
Triplets	Classifier	0.08	0.28	0.30	0.17	0.22
Dropout [3]	Classifier	0.13	0.37	0.49	0.30	0.18
Decov [1]	Classifier	0.08	0.17	0.20	0.27	0.26
Multiverse [4]	Classifier	0.09	0.13	0.36	0.36	0.15
Baseline	Model Regression [6]	0.10	0.25	0.32	0.21	0.20
Baseline	Matching Network [5]	0.24	0.47	0.47	0.27	0.28
Baseline-ft	Classifier	0.11	0.17	0.43	0.19	0.25
<i>ResNet-50</i>						
Baseline	Classifier	0.11	0.18	0.22	0.46	0.40
Baseline	Generation + Classifier	0.18	0.30	0.30	0.46	0.40
SGM	Classifier	0.21	0.25	0.18	0.35	0.29
SGM	Generation + Classifier	0.31	0.36	0.29	0.46	0.34

Table 6: Standard deviation: top-1 accuracy, all classes. *Our methods.

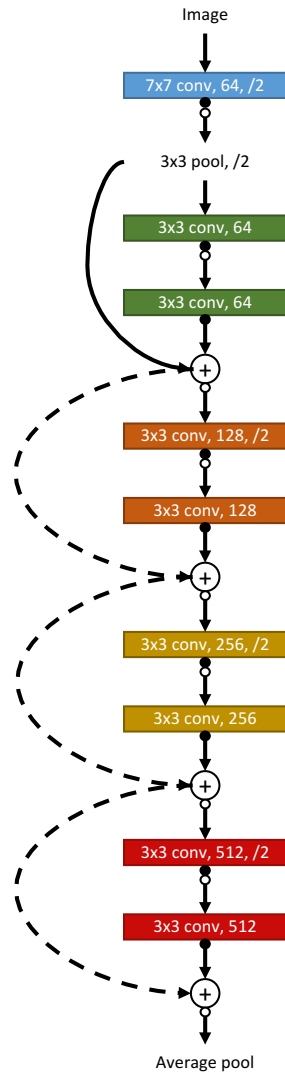


Figure 1: The ResNet-10 architecture. White circles represent ReLU and black circles show batch normalization. Identity shortcuts are shown as solid arrows, while dashed arrows show a 1×1 convolution with stride 2 to match spatial resolution and feature dimension.

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n03841143

Table 7: C_{base}^1

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n01807496	n02916936	n03794056	n01847000	n04044716	n04136333	n11879895	n03534580
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Table 8: C_{base}^2

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Table 9: C_{novel}^1

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n04356056	n03249569	n04037443	n01644373	n03314780	n02487347	n02699494	n03837869
n03125729	n02950826	n03733131	n03887697	n03942813	n03095699	n02807133	n04228054
n02088632	n02280649	n02114712	n03000134	n02110341	n01824575	n04040759	n07717556
n04523525	n01774750	n03599486	n01682714	n04041544	n07760859	n02279972	n02002724
n01955084	n02007558	n01748264	n03935335	n02096585	n03838899	n02281787	n02086079
n04554684	n04229816	n03649909	n03110669	n04447861	n03804744	n02107683	n02025239
n02094433	n03676483	n01855032	n02037110	n09421951	n02093991	n04328186	n03899768
n02493509	n01768244	n03633091	n02116738	n03657121	n03895866	n01978287	n09193705
n03773504	n03146219	n03445777	n02128925	n07753592	n02128385	n02111889	n04442312
n03325584	n02797295	n02088094	n02092339	n01729322	n04487081	n03598930	n01667778
n02787622	n07718472	n07754684	n03938244	n02219486	n03791053	n06794110	n01917289
n03958227	n03018349	n02113712	n03980874	n03530642	n02483708	n01644900	n02497673
n04461696	n03733805	n03710721	n04458633	n01984695	n04357314	n01689811	n03803284
n03944341	n12620546	n03680355	n02672831	n02110627	n07716358	n04238763	n03891332
n02132136	n02105251	n03133878	n03825788	n01828970	n01877812	n04355933	n03891251
n04380533	n02113186	n02017213	n02013706	n02108089	n02097130	n02963159	n03857828
n02190166	n03459775	n01774384	n02817516	n07836838	n04347754	n03690938	n01744401
n04008634	n01664065	n01631663	n02104029	n07590611	n02108422	n02094258	n01629819
n07714990	n07920052	n03180011	n03255030	n01531178	n03775546	n01843383	n04141327
n01692333	n03207743	n04398044	n03063689	n02101388	n03709823	n07614500	n02110063
n04127249	n02085620	n04263257	n02129165	n02129604	n09288635	n02102973	n02788148
n03424325	n02490219	n02231487	n02106382	n02229544	n01930112	n03642806	n04067472
n02106166	n04536866	n02098286	n01518878	n01440764	n02444819	n02484975	n02093859
n03868242	n03223299	n02869837	n02346627	n03017168	n02906734	n02105162	n02860847
n01498041	n02793495	n02730930	n02088466	n03337140	n01944390	n04311174	n03782006
n04399382	n02172182	n03447721	n09472597	n09332890	n07716906	n03876231	n03028079
n02777292	n02110958	n01514668	n03047690	n02892201	n01775062	n04370456	n03100240
n03063599	n01753488	n01667114	n04133789	n02133161	n02018795	n07684084	n03595614
n02099849	n02098105	n04004767	n02840245	n04355338	n03109150	n02165105	n02325366
n02138441	n03840681	n02093256	n03065424	n02127052	n04592741	n02105505	n04273569
n02494079	n02790996	n02134418	n10148035	n03160309	n02981792	n04009552	n03977966
n03584254	n04371774	n02102040	n04596742	n02111277	n01669191	n03492542	

Table 10: C_{novel}^2