Logit

    paper

        logits[0] = depth_ratio * depth_mean + cla_ratio * logits[0]

        logits[1] = 1.0 - depth_mean

    normal

        logits[0]

        logits[1]

loss

    CEP: cross-entropy

    PAPER: loss = loss_reg + depth_ratio * loss_depth + cla_ratio * loss_cla

Model

Dataset	Logit	acc_mean	apcer	bpcer	acer
OULU_1 (19501)	paper	0.9591	0.1512	0.0128	0.0820
OULU_1 (19501)	normal	0.9625	0.0420	0.0363	0.0392
OULU_2	paper	0.4883	0.00279	0.76718	0.384987
OULU_2	normal	0.3343	0	1	0.5
OULU_2 (19501)	paper	0.9580	0.0698	0.0280	0.04894
OULU_2 (19501)	normal	0.9430	0.0279	0.0715	0.04973
OULU_3	paper	0.8304	0.0043	0.8135	0.4089
OULU_3	normal	0.8166	0.0870	0.5593	0.3231
OULU_3 (19501)	paper	0.9515	0.0348	0.1017	0.0682
OULU_3 (19501)	normal	0.9274	0.0826	0.0339	0.0583
OULU_4	paper	0.7777	0	0.6316	0.3158
OULU_4	normal	0.7593	0.1143	0.4737	0.2940
OULU_4 (19501)	paper	0.9444	0	0.1579	0.0789
OULU_4 (19501)	normal	0.9815	0	0.0526	0.0263
replayattack	paper	0.9479	0.1625	0.03	0.09625

replayattack	normal	0.9125	0.025	0.1	0.0625
CASIA	paper	0.7742	1	0	0.5
CASIA	normal	0.8459	0.6190	0.0185	0.3188
CASIA(backup)	paper	0.8243	0.7777	0	0.3889
CASIA(backup)	normal	0.8387	0.6349	0.0231	0.3290
CASIA(19501)	paper	0.7885	0.9365	0	0.4683
CASIA(19501)	normal	0.9175	0.3016	0.0185	0.1601
MSU	paper	0.7651	0.1818	0.3846	0.2832
MSU	normal	0.2617	1	0	0.5
MSU(19501)	paper	0.9060	0.0364	0.2564	0.1464
MSU(19501)	normal	0.9329	0.0727	0.0513	0.0620

(19501): train from checkpoint 19501

FGSM

OULU_1 (19501)

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9591	0.1512	0.0128	0.0820
normal	0.9625	0.0420	0.0363	0.0392

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	CEP	1	0.9202	415	36	17
0.3	normal	CEP	2	0	0	451	17
0.4	normal	CEP	1	0.9978	415	36	17
0.4	normal	CEP	2	0	0	451	17
0.5	normal	CEP	1	1	451	0	17
0.5	normal	CEP	2	0.0089	4	447	17
0.5	normal	PAPER	1	1	451	0	17
0.5	normal	PAPER	2	0.0089	4	447	17
0.5	PAPER	PAPER	1	0	0	462	6
0.5	PAPER	PAPER	2	0	0	462	6

OULU_1 (19501) no [0.5 0.5]

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9642	0.0256	0.0756	0.0506
normal	0.9574	0.0449	0.0336	0.0392

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.05	normal	CEP	1	0.1566	70	377	21
0.05	normal	CEP	2	0.1566	70	377	21
0.07	normal	CEP	1	0.0425	19	428	21
0.07	normal	CEP	2	0.0425	19	428	21
0.08	normal	CEP	1	0.0291	13	434	21
0.08	normal	CEP	2	0.0291	13	434	21
0.1	normal	CEP	1	0.0111	5	442	21
0.1	normal	CEP	2	0.0111	5	442	21
0.2	normal	CEP	1	0	0	447	21
0.2	normal	CEP	2	0	0	447	21
0.3	normal	CEP	1	0	0	447	21
0.3	normal	CEP	2	0	0	447	21
0.4	normal	CEP	1	0.0089	4	443	21
0.4	normal	CEP	2	0.0089	4	443	21
0.5	normal	CEP	1	0.0761	34	413	21
0.5	normal	CEP	2	0.0761	34	413	21
0.6	normal	CEP	1	0.1409	63	384	21
0.6	normal	CEP	2	0.1409	63	384	21
0.7	normal	CEP	1	0.1902	85	362	21
0.7	normal	CEP	2	0.1902	85	362	21
0.8	normal	CEP	1	0.2192	98	349	21
0.8	normal	CEP	2	0.2192	98	349	21
0.9	normal	CEP	1	0.2617	117	330	21
0.9	normal	CEP	2	0.2617	117	330	21

FILTER 1

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	CEP	1	0.6085	272	175	21
0.3	normal	CEP	2				
0.4	normal	CEP	1	0.5638	252	195	21
0.4	normal	CEP	2				

FILTER 2

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	CEP	1	0.1208	54	393	21
0.3	normal	CEP	2				
0.4	normal	CEP	1	0.2036	91	356	21
0.4	normal	CEP	2				

FILTER 3

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	CEP	1	0.0850	38	409	21
0.3	normal	CEP	2				
0.4	normal	CEP	1	0.0917	41	406	21
0.4	normal	CEP	2				

OULU_2 (19501)

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9580	0.0698	0.0280	0.04894
normal	0.9430	0.0279	0.0715	0.04973

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.01	normal	CEP	1	0	0	662	51

0.01	normal	CEP	2	0	0	662	51
0.05	normal	CEP	1	0	0	662	51
0.05	normal	CEP	2	0	0	662	51
0.1	normal	CEP	1	0	0	662	51
0.1	normal	CEP	2	0	0	662	51
0.2	normal	CEP	1	0	0	662	51
0.2	normal	CEP	2	0	0	662	51
0.3	PAPER	PAPER	1	0	0	693	20
0.3	PAPER	PAPER	2	0	0	693	20
0.3	normal	CEP	1	0	0	662	51
0.3	normal	CEP	2	0	0	662	51
0.4	normal	CEP	1	0.0423	28	634	51
0.4	normal	CEP	2	0.0423	28	634	51
0.5	PAPER	PAPER	1	0	0	693	20
0.5	PAPER	PAPER	2	0	0	693	20
0.5	normal	CEP	1	0	0	662	51
0.5	normal	CEP	2	0	0	662	51
0.6	normal	CEP	1	0.3278	217	445	51
0.6	normal	CEP	2	0.3278	217	445	51
0.7	normal	CEP	1	0.3897	258	404	51
0.7	normal	CEP	2	0.3897	258	404	51
0.8	normal	CEP	1	0.4486	297	365	51
0.8	normal	CEP	2	0.4486	297	365	51
0.9	normal	CEP	1	0.5	331	331	51
0.9	normal	CEP	2	0.5	331	331	51
1	normal	CEP	1	0.5695	377	285	51
1	normal	CEP	2	0.5695	377	285	51

OULU_3 (19501)

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9515	0.0348	0.1017	0.0682
normal	0.9274	0.0826	0.0339	0.0583

Attack

epsilon	logit	loss	type	ASR(%)	Attack	Attack	Test

					Success	Fail	Real
0.01	normal	CEP	1	0	0	211	19
0.01	normal	CEP	2	0	0	211	19
0.05	normal	CEP	1	0	0	211	19
0.05	normal	CEP	2	0	0	211	19
0.07	normal	CEP	1	0.0711	15	196	19
0.07	normal	CEP	2	0.0711	15	196	19
0.08	normal	CEP	1	0.0521	11	200	19
0.08	normal	CEP	2	0.0521	11	200	19
0.1	normal	CEP	1	0	0	211	19
0.1	normal	CEP	2	0	0	211	19
0.3	normal	CEP	1	0	0	211	19
0.3	normal	CEP	2	0	0	211	19
0.4	normal	CEP	1	0.0047	1	210	19
0.4	normal	CEP	2	0.0047	1	210	19
0.5	normal	CEP	1	0.0047	1	210	19
0.5	normal	CEP	2	0.0047	1	210	19
0.6	normal	CEP	1	0.0189	4	207	19
0.6	normal	CEP	2	0.0189	4	207	19
0.7	normal	CEP	1	0.0995	21	190	19
0.7	normal	CEP	2	0.0995	21	190	19
0.8	normal	CEP	1	0.1611	34	177	19
0.8	normal	CEP	2	0.1611	34	177	19
0.9	normal	CEP	1	0.1896	40	171	19
0.9	normal	CEP	2	0.1896	40	171	19
1	normal	CEP	1	0.2275	48	163	19
1	normal	CEP	2	0.2275	48	163	19

FILTER 2

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	CEP	1	0.2559	54	157	19
0.3	normal	CEP	2				
0.4	normal	CEP	1	0.3934	83	128	19
0.4	normal	CEP	2				

OULU_4 (19501)

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9515	0.0348	0.1017	0.0682
normal	0.9274	0.0826	0.0339	0.0583

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.01	normal	CEP	1	0.1428	5	30	0
0.01	normal	CEP	2	0.1428	5	30	0
0.05	normal	CEP	1	0.0285	1	34	0
0.05	normal	CEP	2	0.0285	1	34	0
0.07	normal	CEP	1	0.0286	1	34	0
0.07	normal	CEP	2	0.0286	1	34	0
0.08	normal	CEP	1	0	0	35	0
0.08	normal	CEP	2	0	0	35	0
0.1	normal	CEP	1	0	0	35	0
0.1	normal	CEP	2	0	0	35	0
0.13	normal	CEP	1	0	0	35	0
0.13	normal	CEP	2	0	0	35	0
0.2	normal	CEP	1	0	0	35	0
0.2	normal	CEP	2	0	0	35	0
0.3	normal	CEP	1	0	0	35	0
0.3	normal	CEP	2	0	0	35	0
0.4	normal	CEP	1	0.0571	2	33	0
0.4	normal	CEP	2	0.0571	2	33	0
0.5	normal	CEP	1	0.1142	4	31	0
0.5	normal	CEP	2	0.1142	4	31	0
0.6	normal	CEP	1	0.1142	4	31	0
0.6	normal	CEP	2	0.1142	4	31	0
0.7	normal	CEP	1	0.1142	4	31	0
0.7	normal	CEP	2	0.1142	4	31	0
0.8	normal	CEP	1	0.1142	4	31	0
0.8	normal	CEP	2	0.1142	4	31	0

0.9	normal	CEP	1	0.1142	4	31	0
0.9	normal	CEP	2	0.1142	4	31	0
1	normal	CEP	1	0.1142	4	31	0
1	normal	CEP	2	0.1142	4	31	0

Replay Attack

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9479	0.1625	0.03	0.09625
normal	0.9125	0.025	0.1	0.0625

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	CEP	1	0.1722	62	298	40
0.3	normal	CEP	2	0.1722	62	298	40
0.4	normal	CEP	1	0.2222	80	280	40
0.4	normal	CEP	2	0.2222	80	280	40
0.5	normal	CEP	1	0.2917	105	255	40
0.5	normal	CEP	2	0.2917	105	255	40
0.5	normal	PAPER	1	0.3028	109	251	40
0.5	normal	PAPER	2	0.3028	109	251	40
0.6	normal	CEP	1	0.3055	110	250	40
0.6	normal	CEP	2	0.3055	110	250	40

CASIA(19501)

Model

Logit	acc_mean	apcer	bpcer	acer
paper	paper	0.7885	0.9365	0
normal	normal	0.9175	0.3016	0.0185

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real

0.05	normal	CEP	1	0.0047	1	211	4
0.05	normal	CEP	2	0.0047	1	211	4
0.07	normal	CEP	1	0	0	212	4
0.07	normal	CEP	2	0	0	212	4
0.08	normal	CEP	1	0	0	212	4
0.08	normal	CEP	2	0	0	212	4
0.1	normal	CEP	1	0	0	212	4
0.1	normal	CEP	2	0	0	212	4
0.3	normal	CEP	1	0	0	212	4
0.3	normal	CEP	2	0	0	212	4
0.35	normal	CEP	1	0.0660	14	198	4
0.35	normal	CEP	2	0.0660	14	198	4
0.4	normal	CEP	1	0.4575	97	115	4
0.4	normal	CEP	2	0.4575	97	115	4
0.45	normal	CEP	1	0.8679	184	28	4
0.45	normal	CEP	2	0.8679	184	28	4
0.5	normal	CEP	1	0.9340	198	14	4
0.5	normal	CEP	2	0.9340	197	15	4
0.6	normal	CEP	1	0.9528	202	10	4
0.6	normal	CEP	2	0.9528	202	10	4

CASIA

Model

Logit	acc_mean	apcer	bpcer	acer
paper	paper	0.7742	1	0
normal	normal	0.8459	0.6190	0.0185

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	PAPER	PAPER	1	0	0	216	0
0.3	PAPER	PAPER	2	0	0	216	0
0.3	normal	CEP	1	0	0	212	4
0.3	normal	CEP	2	0	0	212	4
0.5	PAPER	PAPER	1	0	0	216	0

0.5	PAPER	PAPER	2	0	0	216	0

MSU

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9060	0.0364	0.2564	0.1464
normal	0.9329	0.0727	0.0513	0.0620

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	CEP	1	0.3627	37	65	8
0.3	normal	CEP	2	0.3627	37	65	8
0.4	normal	CEP	1	0.3825	39	63	8
0.4	normal	CEP	2	0.3825	39	63	8
0.5	normal	CEP	1	0.3627	37	65	8
0.5	normal	CEP	2	0.3627	37	65	8
0.6	normal	CEP	1	0.3825	39	63	8
0.6	normal	CEP	2	0.3825	39	63	8

iFGSM

OULU_1 (19501)

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9591	0.1512	0.0128	0.0820
normal	0.9625	0.0420	0.0363	0.0392

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	CEP	1	0.9091	410	41	17
0.3	normal	CEP	2	0.5964	269	182	17
0.3	PAPER	PAPER	1	0.01948	9	453	6
0.3	PAPER	PAPER	2	0.01948	9	453	6

OULU_1 (19501) no [0.5 0.5]

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9642	0.0256	0.0756	0.0506
normal	0.9574	0.0449	0.0336	0.0392

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.05	normal	CEP	1	0.3691	135	282	21
0.05	normal	CEP	2	0.3691	135	282	21
0.1	normal	CEP	1	0.3020	135	312	21
0.1	normal	CEP	2	0.3020	135	312	21
0.3	normal	CEP	1	0.4698	210	237	21
0.3	normal	CEP	2	0.4698	210	237	21
0.4	normal	CEP	1	0.4944	221	226	21
0.4	normal	CEP	2	0.4944	221	226	21
0.5	normal	CEP	1	0.5168	231	216	21
0.5	normal	CEP	2	0.5168	231	216	21
0.6	normal	CEP	1	0.5369	240	207	21
0.6	normal	CEP	2	0.5369	240	207	21

OULU_2 (19501)

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9580	0.0698	0.0280	0.04894
normal	0.9430	0.0279	0.0715	0.04973

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.05	normal	CEP	1	0.3474	230	432	51
0.05	normal	CEP	2	0.3474	230	432	51
0.1	normal	CEP	1	0.2931	194	468	51

0.1	normal	CEP	2	0.2931	194	468	51
0.3	normal	CEP	1	0.6903	457	205	51
0.3	normal	CEP	2	0.6903	457	205	51
0.4	normal	CEP	1	0.7583	502	160	51
0.4	normal	CEP	2	0.7583	502	160	51
0.5	normal	CEP	1	0.8082	535	127	51
0.5	normal	CEP	2	0.8082	535	127	51
0.6	normal	CEP	1	0.8278	548	114	51
0.6	normal	CEP	2	0.8278	548	114	51

OULU_3 (19501)

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9515	0.0348	0.1017	0.0682
normal	0.9274	0.0826	0.0339	0.0583

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.05	normal	CEP	1	0.2322	49	162	19
0.05	normal	CEP	2	0.2322	49	162	19
0.08	normal	CEP	1	0.2180	46	165	19
0.08	normal	CEP	2	0.2180	46	165	19
0.1	normal	CEP	1	0.2132	45	166	19
0.1	normal	CEP	2	0.2132	45	166	19
0.3	PAPER	PAPER	1				
0.3	PAPER	PAPER	2				
0.3	normal	CEP	1	0.6019	127	84	19
0.3	normal	CEP	2	0.6019	127	84	19
0.4	normal	CEP	1	0.6540	138	73	19
0.4	normal	CEP	2	0.6540	138	73	19
0.5	normal	CEP	1	0.6635	140	71	19
0.5	normal	CEP	2	0.6635	140	71	19
0.6	normal	CEP	1	0.7014	148	63	19
0.6	normal	CEP	2	0.7014	148	63	19

OULU_4 (19501)

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9515	0.0348	0.1017	0.0682
normal	0.9274	0.0826	0.0339	0.0583

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.05	normal	CEP	1	0.0285	1	34	0
0.05	normal	CEP	2	0.0285	1	34	0
0.1	normal	CEP	1	0.0571	2	33	0
0.1	normal	CEP	2	0.0571	2	33	0
0.13	normal	CEP	1	0.0571	2	33	0
0.13	normal	CEP	2	0.0571	2	33	0
0.15	normal	CEP	1	0.0857	3	32	0
0.15	normal	CEP	2	0.0857	3	32	0
0.17	normal	CEP	1	0.2286	8	27	0
0.17	normal	CEP	2	0.2286	8	27	0
0.18	normal	CEP	1	0.2857	10	25	0
0.18	normal	CEP	2	0.2857	10	25	0
0.2	normal	CEP	1	0.4286	15	20	0
0.2	normal	CEP	2	0.4286	15	20	0
0.3	normal	CEP	1	0.5143	18	17	0
0.3	normal	CEP	2	0.5143	18	17	0
0.4	normal	CEP	1	0.5714	20	15	0
0.4	normal	CEP	2	0.5714	20	15	0
0.5	normal	CEP	1	0.5714	20	15	0
0.5	normal	CEP	2	0.5714	20	15	0
0.6	normal	CEP	1	0.5714	20	15	0
0.6	normal	CEP	2	0.5714	20	15	0

Replay Attack

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9479	0.1625	0.03	0.09625
normal	0.9125	0.025	0.1	0.0625

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	PAPER	1	0.1556	56	304	40
0.3	normal	PAPER	2	0.1556	56	304	40
0.4	normal	PAPER	1	0.1639	59	301	40
0.4	normal	PAPER	2	0.1639	59	301	40
0.5	normal	CEP	1	0.9806	353	7	40
0.5	normal	CEP	2	0.9806	353	7	40
0.5	normal	PAPER	1	0.9916	357	3	40
0.5	normal	PAPER	2	0.9916	357	3	40
0.5	normal	CEP	1	0.1944	70	290	40
0.6	normal	CEP	1	0.2556	92	268	40

CASIA(19501)

Model

Logit	acc_mean	apcer	bpcer	acer
paper	paper	0.7885	0.9365	0
normal	normal	0.9175	0.3016	0.0185

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	CEP	1	0.0425	9	203	4
0.3	normal	CEP	2	0.0425	9	203	4
0.4	normal	CEP	1	0.1226	26	186	4
0.4	normal	CEP	2	0.1226	26	186	4
0.5	normal	CEP	1	0.2972	36	149	4
0.5	normal	CEP	2	0.2972	36	149	4
0.6	normal	CEP	1	0.5472	116	96	4
0.6	normal	CEP	2	0.5472	116	96	4

MSU

Model

Logit	acc_mean	apcer	bpcer	acer
paper	0.9060	0.0364	0.2564	0.1464
normal	0.9329	0.0727	0.0513	0.0620

Attack

epsilon	logit	loss	type	ASR(%)	Attack Success	Attack Fail	Test Real
0.3	normal	CEP	1	0.2843	29	73	8
0.3	normal	CEP	2	0.2843	29	73	8
0.4	normal	CEP	1	0.2941	30	72	8
0.4	normal	CEP	2	0.2941	30	72	8
0.5	normal	CEP	1	0.3333	34	68	8
0.5	normal	CEP	2	0.3333	34	68	8
0.6	normal	CEP	1	0.4706	48	54	8
0.6	normal	CEP	2	0.4706	48	54	8