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 | SSIM |
| 0.05 | normal | CEP | 1 | 0.1566 | 70 | 377 | 21 | 0.7572 |
| 0.05 | normal | CEP | 2 | 0.1566 | 70 | 377 | 21 |  |
| 0.07 | normal | CEP | 1 | 0.0425 | 19 | 428 | 21 | 0.6656 |
| 0.07 | normal | CEP | 2 | 0.0425 | 19 | 428 | 21 |  |
| 0.08 | normal | CEP | 1 | 0.0291 | 13 | 434 | 21 | 0.5866 |
| 0.08 | normal | CEP | 2 | 0.0291 | 13 | 434 | 21 |  |
| 0.1 | normal | CEP | 1 | 0.0111 | 5 | 442 | 21 | 0.5205 |
| 0.1 | normal | CEP | 2 | 0.0111 | 5 | 442 | 21 |  |
| 0.2 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.2820 |
| 0.2 | normal | CEP | 2 | 0 | 0 | 447 | 21 |  |
| 0.3 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.1816 |
| 0.3 | normal | CEP | 2 | 0 | 0 | 447 | 21 |  |
| 0.4 | normal | CEP | 1 | 0.0089 | 4 | 443 | 21 | 0.1288 |
| 0.4 | normal | CEP | 2 | 0.0089 | 4 | 443 | 21 |  |
| 0.5 | normal | CEP | 1 | 0.0761 | 34 | 413 | 21 | 0.0958 |
| 0.5 | normal | CEP | 2 | 0.0761 | 34 | 413 | 21 |  |
| 0.6 | normal | CEP | 1 | 0.1409 | 63 | 384 | 21 | 0.0725 |
| 0.6 | normal | CEP | 2 | 0.1409 | 63 | 384 | 21 |  |
| 0.7 | normal | CEP | 1 | 0.1902 | 85 | 362 | 21 | 0.0562 |
| 0.7 | normal | CEP | 2 | 0.1902 | 85 | 362 | 21 |  |
| 0.8 | normal | CEP | 1 | 0.2192 | 98 | 349 | 21 | 0.0444 |
| 0.8 | normal | CEP | 2 | 0.2192 | 98 | 349 | 21 |  |
| 0.9 | normal | CEP | 1 | 0.2617 | 117 | 330 | 21 | 0.0357 |
| 0.9 | normal | CEP | 2 | 0.2617 | 117 | 330 | 21 |  |

FILTER 1-1 (sigma=1) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.01 | normal | CEP | 1 | 0.3982 | 178 | 269 | 21 | 0.9977 |
| 0.01 | normal | CEP | 2 |  |  |  |  |  |
| 0.03 | normal | CEP | 1 | 0.6420 | 287 | 160 | 21 | 0.9950 |
| 0.03 | normal | CEP | 2 |  |  |  |  |  |
| 0.05 | normal | CEP | 1 | 0.6689 | 299 | 148 | 21 | 0.9879 |
| 0.05 | normal | CEP | 2 |  |  |  |  |  |
| 0.1 | normal | CEP | 1 | 0.6667 | 298 | 149 | 21 | 0.9597 |
| 0.1 | normal | CEP | 2 |  |  |  |  |  |
| 0.2 | normal | CEP | 1 | 0.6421 | 287 | 160 | 21 | 0.8767 |
| 0.2 | normal | CEP | 2 |  |  |  |  |  |
| 0.3 | normal | CEP | 1 | 0.6085 | 272 | 175 | 21 | 0.7833 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.5638 | 252 | 195 | 21 | 0.6961 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |
| 0.5 | normal | CEP | 1 | 0.4855 | 217 | 230 | 21 | 0.6202 |
| 0.5 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1(sigma=1 filter \* 2) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.5928 | 265 | 182 | 21 | 0.9179 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.5951 | 266 | 181 | 21 | 0.8739 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-2(sigma=1) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1208 | 54 | 393 | 21 | 0.6719 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.2036 | 91 | 356 | 21 | 0.5921 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-3(sigma=1) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0850 | 38 | 409 | 21 | 0.8130 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0917 | 41 | 406 | 21 | 0.7720 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 (sigma=1) 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0022 | 1 | 446 | 21 | 0.5187 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.4153 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-2(sigma=1) 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 0 | 21 | 0.4769 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 0 | 21 | 0.3757 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-3(sigma=1) 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0134 | 6 | 441 | 21 | 0.6706 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0045 | 2 | 445 | 21 | 0.5728 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-1 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.3110 | 139 | 308 | 21 | 0.7063 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.1186 | 53 | 394 | 21 | 0.6093 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-2 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0134 | 6 | 441 | 21 | 0.7686 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0044 | 2 | 445 | 21 | 0.5195 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-3 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0134 | 6 | 441 | 21 | 0.7686 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0291 | 13 | 434 | 21 | 0.5195 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-1 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0022 | 1 | 446 | 21 | 0.4612 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.3626 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-2 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.4278 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.3311 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-3 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0045 |  |  | 21 | 0.5982 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 |  |  | 21 | 0.4955 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 (sigma=0.5) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.8660 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.8011 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 (sigma=0.8) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.3893 | 174 | 273 | 21 | 0.6526 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.1588 | 71 | 376 | 21 | 0.5500 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 (sigma=0.8 filter \* 2) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 |  |  |  |  |  |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.6264 | 280 | 167 | 21 | 0.7692 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1(sigma=1.2) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.6264 | 280 | 167 | 21 | 0.8660 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.6286 | 281 | 166 | 21 | 0.8011 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1(sigma=1.4) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.6018 | 269 | 178 | 21 | 0.9153 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.5996 | 268 | 179 | 21 | 0.8701 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1(sigma=2) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.03 | normal | CEP | 1 | 0.0738 | 33 | 414 | 21 | 0.9979 |
| 0.03 | normal | CEP | 2 |  |  |  |  |  |
| 0.05 | normal | CEP | 1 | 0.1252 | 56 | 391 | 21 | 0.9974 |
| 0.05 | normal | CEP | 2 |  |  |  |  |  |
| 0.1 | normal | CEP | 1 | 0.2371 | 106 | 341 | 21 | 0.9942 |
| 0.1 | normal | CEP | 2 |  |  |  |  |  |
| 0.2 | normal | CEP | 1 | 0.3266 | 146 | 301 | 21 | 0.9843 |
| 0.2 | normal | CEP | 2 |  |  |  |  |  |
| 0.3 | normal | CEP | 1 | 0.3781 | 169 | 278 | 21 | 0.9717 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.4116 | 184 | 263 | 21 | 0.9566 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-2(sigma=2) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1275 | 57 | 390 | 21 | 0.7439 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.1633 | 73 | 374 | 21 | 0.7253 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-3(sigma=2) 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0045 | 2 | 445 | 21 | 0.7886 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.8025 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 + SMOOTH 2

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.4228 | 189 | 258 | 21 | 0.8326 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.4698 | 210 | 237 | 21 | 0.7612 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 + SMOOTH 1

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.6443 | 288 | 159 | 21 | 0.9473 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.6353 | 284 | 163 | 21 | 0.9166 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

SMOOTH 1

Attack

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real |
| 0.3 | normal | CEP | 1 | 0.0268 | 12 | 435 | 21 |
| 0.3 | normal | CEP | 2 |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0022 | 1 | 446 | 21 |
| 0.4 | normal | CEP | 2 |  |  |  |  |

SMOOTH 2

Attack

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real |
| 0.3 | normal | CEP | 1 | 0 | 0 | 447 | 21 |
| 0.3 | normal | CEP | 2 |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 447 | 21 |
| 0.4 | normal | CEP | 2 |  |  |  |  |

SMOOTH MORE 1

Attack

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real |
| 0.3 | normal | CEP | 1 | 0 | 0 | 447 | 21 |
| 0.3 | normal | CEP | 2 |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 447 | 21 |
| 0.4 | normal | CEP | 2 |  |  |  |  |

SMOOTH MORE 2

Attack

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real |
| 0.3 | normal | CEP | 1 | 0 | 0 | 447 | 21 |
| 0.3 | normal | CEP | 2 |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 447 | 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 | SSIM |
| 0.01 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9811 |
| 0.01 | normal | CEP | 2 | 0 | 0 | 662 | 51 |  |
| 0.05 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.7675 |
| 0.05 | normal | CEP | 2 | 0 | 0 | 662 | 51 |  |
| 0.1 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.5356 |
| 0.1 | normal | CEP | 2 | 0 | 0 | 662 | 51 |  |
| 0.2 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.2940 |
| 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 | 0.1906 |
| 0.3 | normal | CEP | 2 | 0 | 0 | 662 | 51 |  |
| 0.4 | normal | CEP | 1 | 0.0423 | 28 | 634 | 51 | 0.1365 |
| 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 | 0.4401 |
| 0.5 | normal | CEP | 2 | 0 | 0 | 662 | 51 |  |
| 0.6 | normal | CEP | 1 | 0.3278 | 217 | 445 | 51 | 0.0780 |
| 0.6 | normal | CEP | 2 | 0.3278 | 217 | 445 | 51 |  |
| 0.7 | normal | CEP | 1 | 0.3897 | 258 | 404 | 51 | 0.0611 |
| 0.7 | normal | CEP | 2 | 0.3897 | 258 | 404 | 51 |  |
| 0.8 | normal | CEP | 1 | 0.4486 | 297 | 365 | 51 | 0.0491 |
| 0.8 | normal | CEP | 2 | 0.4486 | 297 | 365 | 51 |  |
| 0.9 | normal | CEP | 1 | 0.5 | 331 | 331 | 51 | 0.0398 |
| 0.9 | normal | CEP | 2 | 0.5 | 331 | 331 | 51 |  |
| 1 | normal | CEP | 1 | 0.5695 | 377 | 285 | 51 | 0.0322 |
| 1 | normal | CEP | 2 | 0.5695 | 377 | 285 | 51 |  |

FILTER 1-1 3D (sigma=1)

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.05 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9881 |
| 0.05 | normal | CEP | 2 |  |  |  |  |  |
| 0.1 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9605 |
| 0.1 | normal | CEP | 2 |  |  |  |  |  |
| 0.2 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.8803 |
| 0.2 | normal | CEP | 2 |  |  |  |  |  |
| 0.3 | normal | CEP | 1 | 0.0257 | 17 | 645 | 51 | 0.9541 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0634 | 42 | 620 | 51 | 0.9276 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |
| 0.5 | normal | CEP | 1 | 0.0982 | 65 | 597 | 51 | 0.6304 |
| 0.5 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 3D (sigma=1 filter \* 2)

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9803 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9691 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 3D (sigma=0.8)

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0227 | 15 | 647 | 51 | 0.6630 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0211 | 14 | 648 | 51 | 0.5615 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 3D (sigma=0.8 filter \* 2)

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9658 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9460 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 3D (sigma=1.2)

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0015 | 1 | 661 | 51 | 0.8696 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0211 | 14 | 648 | 51 | 0.8067 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |
| 0.5 | normal | CEP | 1 | 0.0982 | 65 | 597 | 51 | 0.9339 |
| 0.5 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 3D (sigma=1.2 filter \* 2)

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9873 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9804 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |
| 0.5 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9727 |
| 0.5 | normal | CEP | 2 |  |  |  |  |  |
| 0.6 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9641 |
| 0.6 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 3D (sigma=2)

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.03 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9980 |
| 0.03 | normal | CEP | 2 |  |  |  |  |  |
| 0.05 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9974 |
| 0.05 | normal | CEP | 2 |  |  |  |  |  |
| 0.1 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9941 |
| 0.1 | normal | CEP | 2 |  |  |  |  |  |
| 0.2 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9842 |
| 0.2 | normal | CEP | 2 |  |  |  |  |  |
| 0.3 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9716 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.9567 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-2 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.8343 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.003 | 2 | 660 | 51 | 0.8090 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-3 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0332 | 22 | 640 | 51 | 0.8109 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0785 | 52 | 610 | 51 | 0.7742 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-1 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1103 | 73 | 589 | 51 | 0.7154 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0483 | 32 | 630 | 51 | 0.6205 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-2 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0423 | 28 | 634 | 51 | 0.6166 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0408 | 24 | 635 | 51 | 0.5304 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-3 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0121 | 8 | 654 | 51 | 0.7716 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0483 | 32 | 630 | 51 | 0.7157 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.5302 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.4267 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-2 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0015 | 1 | 661 | 51 | 0.4878 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0030 | 2 | 660 | 51 | 0.3865 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-3 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0015 | 1 | 661 | 51 | 0.6774 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.5816 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-1 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.7154 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 662 | 51 | 0.6205 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-2 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0015 | 1 | 661 | 51 | 0.6166 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0045 | 3 | 659 | 51 | 0.5304 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-3 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0015 | 1 | 661 | 51 | 0.7716 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0015 | 1 | 661 | 51 | 0.7157 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 + SMOOTH 2

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0045 | 3 | 659 | 51 | 0.8365 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0393 | 26 | 636 | 51 | 0.7672 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

SMOOTH 1

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 662 | 21 | 0.6289 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 662 | 21 | 0.5220 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

SMOOTH 2

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.003 | 2 | 660 | 21 | 0.3480 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.008 | 5 | 657 | 21 | 0.2642 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

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 |
| 0.01 | 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 1-2 3D

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 | SSIM |
| 0.05 | normal | CEP | 1 | 0.3691 | 135 | 282 | 21 | 0.8152 |
| 0.05 | normal | CEP | 2 | 0.3691 | 135 | 282 | 21 |  |
| 0.1 | normal | CEP | 1 | 0.3020 | 135 | 312 | 21 | 0.6539 |
| 0.1 | normal | CEP | 2 | 0.3020 | 135 | 312 | 21 |  |
| 0.3 | normal | CEP | 1 | 0.4698 | 210 | 237 | 21 | 0.3696 |
| 0.3 | normal | CEP | 2 | 0.4698 | 210 | 237 | 21 |  |
| 0.4 | normal | CEP | 1 | 0.4944 | 221 | 226 | 21 | 0.2978 |
| 0.4 | normal | CEP | 2 | 0.4944 | 221 | 226 | 21 |  |
| 0.5 | normal | CEP | 1 | 0.5168 | 231 | 216 | 21 | 0.2388 |
| 0.5 | normal | CEP | 2 | 0.5168 | 231 | 216 | 21 |  |
| 0.6 | normal | CEP | 1 | 0.5369 | 240 | 207 | 21 | 0.1879 |
| 0.6 | normal | CEP | 2 | 0.5369 | 240 | 207 | 21 |  |

FILTER 1-1 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.03 | normal | CEP | 1 | 0.3266 | 146 | 301 | 21 | 0.9706 |
| 0.03 | normal | CEP | 2 |  |  |  |  |  |
| 0.05 | normal | CEP | 1 | 0.3490 | 156 | 291 | 21 | 0.9497 |
| 0.05 | normal | CEP | 2 |  |  |  |  |  |
| 0.1 | normal | CEP | 1 | 0.2953 | 132 | 315 | 21 | 0.9113 |
| 0.1 | normal | CEP | 2 |  |  |  |  |  |
| 0.2 | normal | CEP | 1 | 0.1252 | 56 | 391 | 21 | 0.8172 |
| 0.2 | normal | CEP | 2 |  |  |  |  |  |
| 0.3 | normal | CEP | 1 | 0.0626 | 28 | 419 | 21 | 0.5982 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.1342 | 60 | 387 | 21 | 0.4955 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-2 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0201 | 9 | 438 | 21 | 0.7164 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0224 | 10 | 437 | 21 | 0.6761 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-3 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0291 | 13 | 434 | 21 | 0. |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0403 | 18 | 429 | 21 | 0.6844 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-1 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0626 | 28 | 419 | 21 | 0.6684 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.1186 | 53 | 394 | 21 | 0.5682 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-2 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.7217 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0 | 0 | 447 | 21 | 0.6712 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-3 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0291 | 13 | 434 | 21 | 0.7297 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0291 | 13 | 434 | 21 | 0.6854 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1141 | 51 | 396 | 21 | 0.5572 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.1767 | 79 | 368 | 21 | 0.4534 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-2 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0470 | 21 | 426 | 21 | 0.6736 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.1655 | 74 | 373 | 21 | 0.5960 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-3 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0089 | 4 | 443 | 21 | 0.6995 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0805 | 36 | 411 | 21 | 0.6297 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-1 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1678 | 75 | 372 | 21 | 0.5233 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.2237 | 100 | 347 | 21 | 0.4225 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-2 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1119 | 50 | 397 | 21 | 0.6456 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.1812 | 81 | 366 | 21 | 0.5571 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-3 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0425 | 19 | 428 | 21 | 0.6774 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.1790 | 80 | 367 | 21 | 0.5939 |
| 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 | SSIM |
| 0.05 | normal | CEP | 1 | 0.3474 | 230 | 432 | 51 | 0.8314 |
| 0.05 | normal | CEP | 2 | 0.3474 | 230 | 432 | 51 |  |
| 0.1 | normal | CEP | 1 | 0.2931 | 194 | 468 | 51 | 0.6846 |
| 0.1 | normal | CEP | 2 | 0.2931 | 194 | 468 | 51 |  |
| 0.3 | normal | CEP | 1 | 0.6903 | 457 | 205 | 51 | 0.4001 |
| 0.3 | normal | CEP | 2 | 0.6903 | 457 | 205 | 51 |  |
| 0.4 | normal | CEP | 1 | 0.7583 | 502 | 160 | 51 | 0.3225 |
| 0.4 | normal | CEP | 2 | 0.7583 | 502 | 160 | 51 |  |
| 0.5 | normal | CEP | 1 | 0.8082 | 535 | 127 | 51 | 0.2553 |
| 0.5 | normal | CEP | 2 | 0.8082 | 535 | 127 | 51 |  |
| 0.6 | normal | CEP | 1 | 0.8278 | 548 | 114 | 51 | 0.1980 |
| 0.6 | normal | CEP | 2 | 0.8278 | 548 | 114 | 51 |  |

FILTER 1-1 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1480 | 98 | 564 | 51 | 0.6819 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.2160 | 143 | 519 | 51 | 0.6369 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-2 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1828 | 121 | 541 | 51 | 0.7105 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.2160 | 143 | 519 | 51 | 0.6369 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-3 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1964 | 130 | 532 | 51 | 0.7142 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.3006 | 199 | 463 | 51 | 0.6782 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-1 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1465 | 97 | 565 | 51 | 0.6829 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.2160 | 143 | 519 | 51 | 0.5878 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-2 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0861 | 57 | 605 | 51 | 0.7175 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.0498 | 33 | 629 | 51 | 0.6686 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-3 3D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1224 | 81 | 581 | 51 | 0.7248 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.1843 | 122 | 540 | 51 | 0.6817 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-1 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.2024 | 134 | 528 | 51 | 0.5812 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.3127 | 207 | 455 | 51 | 0.4796 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-2 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1662 | 110 | 552 | 51 | 0.6753 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.2915 | 193 | 469 | 51 | 0.6005 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 1-3 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.0695 | 46 | 616 | 51 | 0.6971 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.2326 | 154 | 508 | 51 | 0.6295 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-1 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.2553 | 169 | 493 | 51 | 0.5498 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.4048 | 268 | 394 | 51 | 0.4501 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-2 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.2417 | 160 | 502 | 51 | 0.6534 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.3118 | 206 | 456 | 51 | 0.5681 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

FILTER 2-3 2D

Attack

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| epsilon | logit | loss | type | ASR(%) | Attack Success | Attack Fail | Test Real | SSIM |
| 0.3 | normal | CEP | 1 | 0.1722 | 114 | 548 | 51 | 0.6804 |
| 0.3 | normal | CEP | 2 |  |  |  |  |  |
| 0.4 | normal | CEP | 1 | 0.2961 | 196 | 466 | 51 | 0.6004 |
| 0.4 | normal | CEP | 2 |  |  |  |  |  |

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 |

|  |  |  |
| --- | --- | --- |
|  | 0.3 | 0.4 |
| no | 0 | 0.0089 |
| 0.5 | 0 | 0 |
| 1 | 0.6085 | 0.5638 |
| 1.2 | 0.6264 | 0.6286 |
| 1.4 | 0.6018 | 0.5996 |
| 2 | 0.3781 | 0.417 |
|  |  |  |
| no | 0 | 0.0423 |
| 0.8 | 0.0227 | 0.0211 |
| 1 | 0.0257 | 0.0634 |
| 1.2 | 0.0015 | 0.0211 |
| 2 | 0 | 0 |