Model Training

Importing

In [1]:
```
import tensorflow as tf
from tensorflow.keras.optimizers.schedules import InverseTimeDecay
from model.models import Model_1
from testing import test_model, pred_patches
from dataloader import DataLoader
from model.losses import FocalLoss, WBCE
from model.callbacks import UpdateAccuracy
from ops import reconstruct_image
import os
import json
import shutil
import matplotlib.pyplot as plt
import numpy as np
from tqdm import tqdm
from PIL import Image
from tensorflow.keras.utils import to_categorical
from sklearn.metrics import average_precision_score
```

Parameters

In [2]:
```
# load the params-patches.json options
with open(os.path.join('v1', 'params-patches.json')) as param_file:
    params_patches = json.load(param_file)

# load the params-patches.json options
with open(os.path.join('v1', 'params-training.json')) as param_file:
    params_training = json.load(param_file)

#load the params-model.json options
with open(os.path.join('v1', 'params-model.json')) as param_file:
    params_model = json.load(param_file)

#load the shapes.json options
with open('shapes.json') as param_file:
    shapes_json = json.load(param_file)
```

In [3]:
```
patches_path = params_patches['patches_path']

train_path = os.path.join(patches_path, params_patches['train_sub'])
val_path = os.path.join(patches_path, params_patches['val_sub'])
test_path = os.path.join(patches_path, params_patches['test_sub'])
```

Setting Dataloaders

In [4]:
```
dl_train = DataLoader(
    batch_size = params_training['batch_size'],
    data_path=os.path.join(train_path, params_patches['data_sub']),
    label_path=os.path.join(train_path, params_patches['label_sub']),
    patch_size=128,
    opt_bands=8,
```

```
    sar_bands=4,
    num_classes=3,
    shuffle=True#,
    #limit=params_training['patch_limit']
)

dl_val = DataLoader(
    batch_size=params_training['batch_size'],
    data_path=os.path.join(val_path, params_patches['data_sub']),
    label_path=os.path.join(val_path, params_patches['label_sub']),
    patch_size=128,
    opt_bands=8,
    sar_bands=4,
    num_classes=3#,
    #limit=params_training['patch_limit']
)

dl_test = DataLoader(
    batch_size=params_training['batch_size'],
    data_path=os.path.join(test_path, params_patches['data_sub']),
    label_path=os.path.join(test_path, params_patches['label_sub']),
    patch_size=128,
    opt_bands=8,
    sar_bands=4,
    num_classes=3)
```

Model definition

In [5]:

```
model = Model_1(name='modelo_1')

metrics = {
}

weights = [0.05, 0.95, 0.0]

learning_rate = InverseTimeDecay(
    initial_learning_rate=1e-4,
    decay_steps=params_training['learning_reduction']*len(dl_train),
    decay_rate = 0.01,
    staircase=True
    )

optimizers = {
    'opt': tf.keras.optimizers.Adam(learning_rate = learning_rate),
    'sar': tf.keras.optimizers.Adam(learning_rate = learning_rate),
    'fusion': tf.keras.optimizers.Adam(learning_rate = learning_rate),
}

class_indexes = [0, 1]

model.compile(
    optimizers = optimizers,
    loss_fn = WBCE,
    metrics_dict = metrics,
    class_weights = weights,
    class_indexes = class_indexes,
    run_eagerly=params_training['run_eagerly']
)
```

In [6]:

```
callbacks = [
    tf.keras.callbacks.EarlyStopping(
```

```
        monitor='val_combined_f1score',
        patience = params_training['patience'],
        mode = 'max',
        restore_best_weights=True),
    UpdateAccuracy()
]


history = model.fit(
    x=dl_train,
    validation_data=dl_val,
    epochs=params_training['epochs_train'],
    callbacks=callbacks,
    verbose = 1
    )
```

```
Epoch 1/200
330/330 [==============================] - 273s 822ms/step - opt_loss: 0.2461 - sar_
loss: 0.3342 - fusion_loss: 0.2927 - loss: 0.8730 - opt_accuracy: 0.8281 - sar_accur
acy: 0.7994 - fusion_accuracy: 0.8379 - combined_accuracy: 0.8552 - opt_f1score: 0.7
317 - sar_f1score: 0.6091 - fusion_f1score: 0.7151 - combined_f1score: 0.7482 - val_
opt_loss: 0.2128 - val_sar_loss: 0.6172 - val_fusion_loss: 0.5283 - val_loss: 1.3584
- val_opt_accuracy: 0.8307 - val_sar_accuracy: 0.6016 - val_fusion_accuracy: 0.6016
- val_combined_accuracy: 0.6016 - val_opt_f1score: 0.4010 - val_sar_f1score: 6.9364e
-05 - val_fusion_f1score: 1.0409e-04 - val_combined_f1score: 1.0127e-04
Epoch 2/200
330/330 [==============================] - 119s 359ms/step - opt_loss: 0.1809 - sar_
loss: 0.2594 - fusion_loss: 0.1915 - loss: 0.6318 - opt_accuracy: 0.8760 - sar_accur
acy: 0.8328 - fusion_accuracy: 0.8729 - combined_accuracy: 0.8820 - opt_f1score: 0.8
024 - sar_f1score: 0.7003 - fusion_f1score: 0.7927 - combined_f1score: 0.8067 - val_
opt_loss: 0.1438 - val_sar_loss: 0.4200 - val_fusion_loss: 0.3090 - val_loss: 0.8728
- val_opt_accuracy: 0.8822 - val_sar_accuracy: 0.6421 - val_fusion_accuracy: 0.8590
- val_combined_accuracy: 0.8581 - val_opt_f1score: 0.7306 - val_sar_f1score: 0.1119
- val_fusion_f1score: 0.4234 - val_combined_f1score: 0.4224
Epoch 3/200
330/330 [==============================] - 119s 359ms/step - opt_loss: 0.1660 - sar_
loss: 0.2363 - fusion_loss: 0.1718 - loss: 0.5741 - opt_accuracy: 0.8837 - sar_accur
acy: 0.8447 - fusion_accuracy: 0.8796 - combined_accuracy: 0.8890 - opt_f1score: 0.8
140 - sar_f1score: 0.7252 - fusion_f1score: 0.8065 - combined_f1score: 0.8187 - val_
opt_loss: 0.1364 - val_sar_loss: 0.1891 - val_fusion_loss: 0.1291 - val_loss: 0.4546
- val_opt_accuracy: 0.8832 - val_sar_accuracy: 0.8570 - val_fusion_accuracy: 0.8919
- val_combined_accuracy: 0.8895 - val_opt_f1score: 0.7579 - val_sar_f1score: 0.5501
- val_fusion_f1score: 0.7517 - val_combined_f1score: 0.7491
Epoch 4/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.1584 - sar_
loss: 0.2331 - fusion_loss: 0.1626 - loss: 0.5541 - opt_accuracy: 0.8890 - sar_accur
acy: 0.8472 - fusion_accuracy: 0.8840 - combined_accuracy: 0.8936 - opt_f1score: 0.8
204 - sar_f1score: 0.7280 - fusion_f1score: 0.8132 - combined_f1score: 0.8249 - val_
opt_loss: 0.1308 - val_sar_loss: 0.3234 - val_fusion_loss: 0.1377 - val_loss: 0.5920
- val_opt_accuracy: 0.8954 - val_sar_accuracy: 0.8029 - val_fusion_accuracy: 0.8928
- val_combined_accuracy: 0.8933 - val_opt_f1score: 0.7622 - val_sar_f1score: 0.5689
- val_fusion_f1score: 0.7536 - val_combined_f1score: 0.7527
Epoch 5/200
330/330 [==============================] - 118s 358ms/step - opt_loss: 0.1528 - sar_
loss: 0.2179 - fusion_loss: 0.1513 - loss: 0.5221 - opt_accuracy: 0.8911 - sar_accur
acy: 0.8541 - fusion_accuracy: 0.8872 - combined_accuracy: 0.8965 - opt_f1score: 0.8
248 - sar_f1score: 0.7449 - fusion_f1score: 0.8226 - combined_f1score: 0.8330 - val_
opt_loss: 0.1265 - val_sar_loss: 0.2233 - val_fusion_loss: 0.1410 - val_loss: 0.4908
- val_opt_accuracy: 0.8839 - val_sar_accuracy: 0.8428 - val_fusion_accuracy: 0.8795
- val_combined_accuracy: 0.8767 - val_opt_f1score: 0.7653 - val_sar_f1score: 0.5602
- val_fusion_f1score: 0.7285 - val_combined_f1score: 0.7240
Epoch 6/200
330/330 [==============================] - 118s 358ms/step - opt_loss: 0.1469 - sar_
loss: 0.2048 - fusion_loss: 0.1395 - loss: 0.4913 - opt_accuracy: 0.8937 - sar_accur
acy: 0.8590 - fusion_accuracy: 0.8900 - combined_accuracy: 0.8995 - opt_f1score: 0.8
```

```
286 - sar_f1score: 0.7577 - fusion_f1score: 0.8319 - combined_f1score: 0.8418 - val_
opt_loss: 0.1158 - val_sar_loss: 0.1690 - val_fusion_loss: 0.1099 - val_loss: 0.3947
- val_opt_accuracy: 0.8974 - val_sar_accuracy: 0.8370 - val_fusion_accuracy: 0.8904
- val_combined_accuracy: 0.8915 - val_opt_f1score: 0.7788 - val_sar_f1score: 0.6708
- val_fusion_f1score: 0.7820 - val_combined_f1score: 0.7826
Epoch 7/200
330/330 [==============================] - 120s 364ms/step - opt_loss: 0.1362 - sar_
loss: 0.1871 - fusion_loss: 0.1252 - loss: 0.4485 - opt_accuracy: 0.8980 - sar_accur
acy: 0.8645 - fusion_accuracy: 0.8947 - combined_accuracy: 0.9037 - opt_f1score: 0.8
374 - sar_f1score: 0.7765 - fusion_f1score: 0.8450 - combined_f1score: 0.8537 - val_
opt_loss: 0.1151 - val_sar_loss: 0.1836 - val_fusion_loss: 0.1335 - val_loss: 0.4322
- val_opt_accuracy: 0.8950 - val_sar_accuracy: 0.8691 - val_fusion_accuracy: 0.8967
- val_combined_accuracy: 0.8973 - val_opt_f1score: 0.7769 - val_sar_f1score: 0.6315
- val_fusion_f1score: 0.7289 - val_combined_f1score: 0.7371
Epoch 8/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.1315 - sar_
loss: 0.1759 - fusion_loss: 0.1162 - loss: 0.4237 - opt_accuracy: 0.9005 - sar_accur
acy: 0.8687 - fusion_accuracy: 0.8982 - combined_accuracy: 0.9066 - opt_f1score: 0.8
424 - sar_f1score: 0.7880 - fusion_f1score: 0.8532 - combined_f1score: 0.8608 - val_
opt_loss: 0.1157 - val_sar_loss: 0.1733 - val_fusion_loss: 0.1084 - val_loss: 0.3973
- val_opt_accuracy: 0.8984 - val_sar_accuracy: 0.8517 - val_fusion_accuracy: 0.8968
- val_combined_accuracy: 0.8959 - val_opt_f1score: 0.7790 - val_sar_f1score: 0.6969
- val_fusion_f1score: 0.7946 - val_combined_f1score: 0.7962
Epoch 9/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.1299 - sar_
loss: 0.1644 - fusion_loss: 0.1114 - loss: 0.4057 - opt_accuracy: 0.9021 - sar_accur
acy: 0.8720 - fusion_accuracy: 0.9006 - combined_accuracy: 0.9085 - opt_f1score: 0.8
443 - sar_f1score: 0.7989 - fusion_f1score: 0.8584 - combined_f1score: 0.8656 - val_
opt_loss: 0.1235 - val_sar_loss: 0.1733 - val_fusion_loss: 0.1213 - val_loss: 0.4180
- val_opt_accuracy: 0.8842 - val_sar_accuracy: 0.8650 - val_fusion_accuracy: 0.8935
- val_combined_accuracy: 0.8980 - val_opt_f1score: 0.7561 - val_sar_f1score: 0.6889
- val_fusion_f1score: 0.7639 - val_combined_f1score: 0.7621
Epoch 10/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.1224 - sar_
loss: 0.1572 - fusion_loss: 0.1038 - loss: 0.3834 - opt_accuracy: 0.9048 - sar_accur
acy: 0.8742 - fusion_accuracy: 0.9032 - combined_accuracy: 0.9109 - opt_f1score: 0.8
512 - sar_f1score: 0.8060 - fusion_f1score: 0.8652 - combined_f1score: 0.8719 - val_
opt_loss: 0.1073 - val_sar_loss: 0.2367 - val_fusion_loss: 0.0969 - val_loss: 0.4409
- val_opt_accuracy: 0.9037 - val_sar_accuracy: 0.8322 - val_fusion_accuracy: 0.9024
- val_combined_accuracy: 0.9012 - val_opt_f1score: 0.7906 - val_sar_f1score: 0.6330
- val_fusion_f1score: 0.8136 - val_combined_f1score: 0.8095
Epoch 11/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.1187 - sar_
loss: 0.1490 - fusion_loss: 0.0974 - loss: 0.3651 - opt_accuracy: 0.9072 - sar_accur
acy: 0.8781 - fusion_accuracy: 0.9070 - combined_accuracy: 0.9137 - opt_f1score: 0.8
554 - sar_f1score: 0.8148 - fusion_f1score: 0.8724 - combined_f1score: 0.8782 - val_
opt_loss: 0.1259 - val_sar_loss: 0.1487 - val_fusion_loss: 0.1009 - val_loss: 0.3755
- val_opt_accuracy: 0.8976 - val_sar_accuracy: 0.8693 - val_fusion_accuracy: 0.9030
- val_combined_accuracy: 0.9033 - val_opt_f1score: 0.7685 - val_sar_f1score: 0.7301
- val_fusion_f1score: 0.8054 - val_combined_f1score: 0.8059
Epoch 12/200
330/330 [==============================] - 118s 358ms/step - opt_loss: 0.1143 - sar_
loss: 0.1422 - fusion_loss: 0.0934 - loss: 0.3499 - opt_accuracy: 0.9084 - sar_accur
acy: 0.8792 - fusion_accuracy: 0.9083 - combined_accuracy: 0.9145 - opt_f1score: 0.8
600 - sar_f1score: 0.8195 - fusion_f1score: 0.8757 - combined_f1score: 0.8812 - val_
opt_loss: 0.1184 - val_sar_loss: 0.1719 - val_fusion_loss: 0.1213 - val_loss: 0.4115
- val_opt_accuracy: 0.8948 - val_sar_accuracy: 0.8673 - val_fusion_accuracy: 0.8987
- val_combined_accuracy: 0.9026 - val_opt_f1score: 0.7444 - val_sar_f1score: 0.7086
- val_fusion_f1score: 0.7621 - val_combined_f1score: 0.7605
Epoch 13/200
330/330 [==============================] - 118s 357ms/step - opt_loss: 0.1097 - sar_
loss: 0.1362 - fusion_loss: 0.0884 - loss: 0.3343 - opt_accuracy: 0.9111 - sar_accur
acy: 0.8811 - fusion_accuracy: 0.9116 - combined_accuracy: 0.9170 - opt_f1score: 0.8
648 - sar_f1score: 0.8253 - fusion_f1score: 0.8813 - combined_f1score: 0.8858 - val_
opt_loss: 0.1059 - val_sar_loss: 0.1443 - val_fusion_loss: 0.1070 - val_loss: 0.3573
```

```
- val_opt_accuracy: 0.8970 - val_sar_accuracy: 0.8824 - val_fusion_accuracy: 0.8991
- val_combined_accuracy: 0.9016 - val_opt_f1score: 0.8062 - val_sar_f1score: 0.7360
- val_fusion_f1score: 0.8072 - val_combined_f1score: 0.8140
Epoch 14/200
330/330 [==============================] - 118s 357ms/step - opt_loss: 0.1067 - sar_
loss: 0.1307 - fusion_loss: 0.0852 - loss: 0.3226 - opt_accuracy: 0.9124 - sar_accur
acy: 0.8835 - fusion_accuracy: 0.9137 - combined_accuracy: 0.9184 - opt_f1score: 0.8
682 - sar_f1score: 0.8319 - fusion_f1score: 0.8853 - combined_f1score: 0.8893 - val_
opt_loss: 0.1077 - val_sar_loss: 0.1433 - val_fusion_loss: 0.1005 - val_loss: 0.3515
- val_opt_accuracy: 0.9025 - val_sar_accuracy: 0.8664 - val_fusion_accuracy: 0.9002
- val_combined_accuracy: 0.9067 - val_opt_f1score: 0.7966 - val_sar_f1score: 0.7196
- val_fusion_f1score: 0.8007 - val_combined_f1score: 0.8057
Epoch 15/200
330/330 [==============================] - 118s 357ms/step - opt_loss: 0.1025 - sar_
loss: 0.1248 - fusion_loss: 0.0810 - loss: 0.3083 - opt_accuracy: 0.9144 - sar_accur
acy: 0.8871 - fusion_accuracy: 0.9167 - combined_accuracy: 0.9207 - opt_f1score: 0.8
725 - sar_f1score: 0.8383 - fusion_f1score: 0.8905 - combined_f1score: 0.8937 - val_
opt_loss: 0.1013 - val_sar_loss: 0.1551 - val_fusion_loss: 0.1024 - val_loss: 0.3587
- val_opt_accuracy: 0.8959 - val_sar_accuracy: 0.8605 - val_fusion_accuracy: 0.8934
- val_combined_accuracy: 0.8914 - val_opt_f1score: 0.8073 - val_sar_f1score: 0.7393
- val_fusion_f1score: 0.8187 - val_combined_f1score: 0.8170
Epoch 16/200
330/330 [==============================] - 118s 356ms/step - opt_loss: 0.1004 - sar_
loss: 0.1200 - fusion_loss: 0.0782 - loss: 0.2986 - opt_accuracy: 0.9154 - sar_accur
acy: 0.8883 - fusion_accuracy: 0.9182 - combined_accuracy: 0.9214 - opt_f1score: 0.8
750 - sar_f1score: 0.8430 - fusion_f1score: 0.8935 - combined_f1score: 0.8960 - val_
opt_loss: 0.1012 - val_sar_loss: 0.1531 - val_fusion_loss: 0.1030 - val_loss: 0.3573
- val_opt_accuracy: 0.8999 - val_sar_accuracy: 0.8656 - val_fusion_accuracy: 0.8957
- val_combined_accuracy: 0.8963 - val_opt_f1score: 0.8118 - val_sar_f1score: 0.7334
- val_fusion_f1score: 0.8138 - val_combined_f1score: 0.8173
Epoch 17/200
330/330 [==============================] - 118s 357ms/step - opt_loss: 0.0978 - sar_
loss: 0.1152 - fusion_loss: 0.0757 - loss: 0.2886 - opt_accuracy: 0.9171 - sar_accur
acy: 0.8908 - fusion_accuracy: 0.9204 - combined_accuracy: 0.9232 - opt_f1score: 0.8
783 - sar_f1score: 0.8479 - fusion_f1score: 0.8970 - combined_f1score: 0.8991 - val_
opt_loss: 0.1061 - val_sar_loss: 0.1558 - val_fusion_loss: 0.0969 - val_loss: 0.3587
- val_opt_accuracy: 0.8990 - val_sar_accuracy: 0.8636 - val_fusion_accuracy: 0.8983
- val_combined_accuracy: 0.8993 - val_opt_f1score: 0.7989 - val_sar_f1score: 0.7186
- val_fusion_f1score: 0.8297 - val_combined_f1score: 0.8293
Epoch 18/200
330/330 [==============================] - 118s 357ms/step - opt_loss: 0.0928 - sar_
loss: 0.1117 - fusion_loss: 0.0722 - loss: 0.2767 - opt_accuracy: 0.9186 - sar_accur
acy: 0.8917 - fusion_accuracy: 0.9219 - combined_accuracy: 0.9242 - opt_f1score: 0.8
829 - sar_f1score: 0.8516 - fusion_f1score: 0.9004 - combined_f1score: 0.9020 - val_
opt_loss: 0.0926 - val_sar_loss: 0.1395 - val_fusion_loss: 0.0876 - val_loss: 0.3197
- val_opt_accuracy: 0.9036 - val_sar_accuracy: 0.8837 - val_fusion_accuracy: 0.9051
- val_combined_accuracy: 0.9064 - val_opt_f1score: 0.8230 - val_sar_f1score: 0.7644
- val_fusion_f1score: 0.8312 - val_combined_f1score: 0.8340
Epoch 19/200
330/330 [==============================] - 118s 357ms/step - opt_loss: 0.0890 - sar_
loss: 0.1064 - fusion_loss: 0.0688 - loss: 0.2642 - opt_accuracy: 0.9209 - sar_accur
acy: 0.8942 - fusion_accuracy: 0.9247 - combined_accuracy: 0.9266 - opt_f1score: 0.8
873 - sar_f1score: 0.8573 - fusion_f1score: 0.9049 - combined_f1score: 0.9061 - val_
opt_loss: 0.1193 - val_sar_loss: 0.1428 - val_fusion_loss: 0.1211 - val_loss: 0.3833
- val_opt_accuracy: 0.8704 - val_sar_accuracy: 0.8772 - val_fusion_accuracy: 0.8762
- val_combined_accuracy: 0.8849 - val_opt_f1score: 0.7698 - val_sar_f1score: 0.7582
- val_fusion_f1score: 0.7852 - val_combined_f1score: 0.7937
Epoch 20/200
330/330 [==============================] - 120s 363ms/step - opt_loss: 0.0886 - sar_
loss: 0.1054 - fusion_loss: 0.0681 - loss: 0.2622 - opt_accuracy: 0.9211 - sar_accur
acy: 0.8945 - fusion_accuracy: 0.9250 - combined_accuracy: 0.9266 - opt_f1score: 0.8
880 - sar_f1score: 0.8585 - fusion_f1score: 0.9057 - combined_f1score: 0.9065 - val_
opt_loss: 0.0944 - val_sar_loss: 0.1471 - val_fusion_loss: 0.0961 - val_loss: 0.3376
- val_opt_accuracy: 0.9114 - val_sar_accuracy: 0.8810 - val_fusion_accuracy: 0.9126
- val_combined_accuracy: 0.9124 - val_opt_f1score: 0.8211 - val_sar_f1score: 0.7510
```

```
- val_fusion_f1score: 0.8333 - val_combined_f1score: 0.8330
Epoch 21/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0834 - sar_
loss: 0.0999 - fusion_loss: 0.0641 - loss: 0.2474 - opt_accuracy: 0.9233 - sar_accur
acy: 0.8966 - fusion_accuracy: 0.9273 - combined_accuracy: 0.9286 - opt_f1score: 0.8
937 - sar_f1score: 0.8641 - fusion_f1score: 0.9103 - combined_f1score: 0.9109 - val_
opt_loss: 0.0982 - val_sar_loss: 0.1494 - val_fusion_loss: 0.1028 - val_loss: 0.3505
- val_opt_accuracy: 0.9051 - val_sar_accuracy: 0.8853 - val_fusion_accuracy: 0.9043
- val_combined_accuracy: 0.9073 - val_opt_f1score: 0.8261 - val_sar_f1score: 0.7677
- val_fusion_f1score: 0.8344 - val_combined_f1score: 0.8373
Epoch 22/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0833 - sar_
loss: 0.0994 - fusion_loss: 0.0640 - loss: 0.2468 - opt_accuracy: 0.9236 - sar_accur
acy: 0.8960 - fusion_accuracy: 0.9277 - combined_accuracy: 0.9285 - opt_f1score: 0.8
939 - sar_f1score: 0.8635 - fusion_f1score: 0.9107 - combined_f1score: 0.9110 - val_
opt_loss: 0.0897 - val_sar_loss: 0.1450 - val_fusion_loss: 0.0868 - val_loss: 0.3215
- val_opt_accuracy: 0.9144 - val_sar_accuracy: 0.8858 - val_fusion_accuracy: 0.9136
- val_combined_accuracy: 0.9169 - val_opt_f1score: 0.8353 - val_sar_f1score: 0.7664
- val_fusion_f1score: 0.8412 - val_combined_f1score: 0.8455
Epoch 23/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0779 - sar_
loss: 0.0923 - fusion_loss: 0.0596 - loss: 0.2297 - opt_accuracy: 0.9256 - sar_accur
acy: 0.9005 - fusion_accuracy: 0.9301 - combined_accuracy: 0.9308 - opt_f1score: 0.8
991 - sar_f1score: 0.8719 - fusion_f1score: 0.9155 - combined_f1score: 0.9157 - val_
opt_loss: 0.1055 - val_sar_loss: 0.1380 - val_fusion_loss: 0.1009 - val_loss: 0.3444
- val_opt_accuracy: 0.8955 - val_sar_accuracy: 0.8826 - val_fusion_accuracy: 0.9013
- val_combined_accuracy: 0.9059 - val_opt_f1score: 0.8218 - val_sar_f1score: 0.7710
- val_fusion_f1score: 0.8344 - val_combined_f1score: 0.8377
Epoch 24/200
330/330 [==============================] - 119s 362ms/step - opt_loss: 0.0771 - sar_
loss: 0.0913 - fusion_loss: 0.0589 - loss: 0.2273 - opt_accuracy: 0.9266 - sar_accur
acy: 0.9002 - fusion_accuracy: 0.9310 - combined_accuracy: 0.9314 - opt_f1score: 0.9
006 - sar_f1score: 0.8730 - fusion_f1score: 0.9168 - combined_f1score: 0.9167 - val_
opt_loss: 0.1081 - val_sar_loss: 0.1466 - val_fusion_loss: 0.1050 - val_loss: 0.3597
- val_opt_accuracy: 0.9022 - val_sar_accuracy: 0.8855 - val_fusion_accuracy: 0.9051
- val_combined_accuracy: 0.9085 - val_opt_f1score: 0.8064 - val_sar_f1score: 0.7792
- val_fusion_f1score: 0.8293 - val_combined_f1score: 0.8333
Epoch 25/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0759 - sar_
loss: 0.0885 - fusion_loss: 0.0576 - loss: 0.2219 - opt_accuracy: 0.9272 - sar_accur
acy: 0.9009 - fusion_accuracy: 0.9317 - combined_accuracy: 0.9321 - opt_f1score: 0.9
020 - sar_f1score: 0.8753 - fusion_f1score: 0.9181 - combined_f1score: 0.9180 - val_
opt_loss: 0.0972 - val_sar_loss: 0.1691 - val_fusion_loss: 0.1042 - val_loss: 0.3705
- val_opt_accuracy: 0.9103 - val_sar_accuracy: 0.8881 - val_fusion_accuracy: 0.9109
- val_combined_accuracy: 0.9130 - val_opt_f1score: 0.8389 - val_sar_f1score: 0.7654
- val_fusion_f1score: 0.8378 - val_combined_f1score: 0.8427
Epoch 26/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0730 - sar_
loss: 0.0843 - fusion_loss: 0.0550 - loss: 0.2123 - opt_accuracy: 0.9283 - sar_accur
acy: 0.9028 - fusion_accuracy: 0.9329 - combined_accuracy: 0.9331 - opt_f1score: 0.9
049 - sar_f1score: 0.8797 - fusion_f1score: 0.9208 - combined_f1score: 0.9207 - val_
opt_loss: 0.1039 - val_sar_loss: 0.2490 - val_fusion_loss: 0.1482 - val_loss: 0.5012
- val_opt_accuracy: 0.9050 - val_sar_accuracy: 0.8815 - val_fusion_accuracy: 0.9003
- val_combined_accuracy: 0.9045 - val_opt_f1score: 0.8288 - val_sar_f1score: 0.6799
- val_fusion_f1score: 0.7878 - val_combined_f1score: 0.7987
Epoch 27/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0709 - sar_
loss: 0.0847 - fusion_loss: 0.0542 - loss: 0.2098 - opt_accuracy: 0.9293 - sar_accur
acy: 0.9034 - fusion_accuracy: 0.9336 - combined_accuracy: 0.9339 - opt_f1score: 0.9
072 - sar_f1score: 0.8799 - fusion_f1score: 0.9219 - combined_f1score: 0.9218 - val_
opt_loss: 0.1109 - val_sar_loss: 0.1618 - val_fusion_loss: 0.1108 - val_loss: 0.3835
- val_opt_accuracy: 0.8991 - val_sar_accuracy: 0.8766 - val_fusion_accuracy: 0.9034
- val_combined_accuracy: 0.9062 - val_opt_f1score: 0.7955 - val_sar_f1score: 0.7810
- val_fusion_f1score: 0.8237 - val_combined_f1score: 0.8272
Epoch 28/200
```

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330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0706 - sar_
loss: 0.0829 - fusion_loss: 0.0535 - loss: 0.2070 - opt_accuracy: 0.9297 - sar_accur
acy: 0.9041 - fusion_accuracy: 0.9343 - combined_accuracy: 0.9345 - opt_f1score: 0.9
079 - sar_f1score: 0.8819 - fusion_f1score: 0.9229 - combined_f1score: 0.9228 - val_
opt_loss: 0.1023 - val_sar_loss: 0.1836 - val_fusion_loss: 0.0917 - val_loss: 0.3776
- val_opt_accuracy: 0.9112 - val_sar_accuracy: 0.8509 - val_fusion_accuracy: 0.9118
- val_combined_accuracy: 0.9152 - val_opt_f1score: 0.8383 - val_sar_f1score: 0.6889
- val_fusion_f1score: 0.8441 - val_combined_f1score: 0.8450
Epoch 29/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0690 - sar_
loss: 0.0827 - fusion_loss: 0.0525 - loss: 0.2041 - opt_accuracy: 0.9306 - sar_accur
acy: 0.9034 - fusion_accuracy: 0.9349 - combined_accuracy: 0.9349 - opt_f1score: 0.9
097 - sar_f1score: 0.8813 - fusion_f1score: 0.9240 - combined_f1score: 0.9238 - val_
opt_loss: 0.1083 - val_sar_loss: 0.1447 - val_fusion_loss: 0.1017 - val_loss: 0.3547
- val_opt_accuracy: 0.9023 - val_sar_accuracy: 0.8873 - val_fusion_accuracy: 0.9043
- val_combined_accuracy: 0.9048 - val_opt_f1score: 0.8207 - val_sar_f1score: 0.7905
- val_fusion_f1score: 0.8351 - val_combined_f1score: 0.8372
Epoch 30/200
330/330 [==============================] - 120s 362ms/step - opt_loss: 0.0678 - sar_
loss: 0.0794 - fusion_loss: 0.0516 - loss: 0.1988 - opt_accuracy: 0.9308 - sar_accur
acy: 0.9048 - fusion_accuracy: 0.9352 - combined_accuracy: 0.9353 - opt_f1score: 0.9
109 - sar_f1score: 0.8851 - fusion_f1score: 0.9250 - combined_f1score: 0.9248 - val_
opt_loss: 0.1009 - val_sar_loss: 0.1583 - val_fusion_loss: 0.0969 - val_loss: 0.3562
- val_opt_accuracy: 0.9140 - val_sar_accuracy: 0.8881 - val_fusion_accuracy: 0.9146
- val_combined_accuracy: 0.9146 - val_opt_f1score: 0.8429 - val_sar_f1score: 0.7947
- val_fusion_f1score: 0.8504 - val_combined_f1score: 0.8538
Epoch 31/200
330/330 [==============================] - 119s 362ms/step - opt_loss: 0.0643 - sar_
loss: 0.0788 - fusion_loss: 0.0492 - loss: 0.1923 - opt_accuracy: 0.9330 - sar_accur
acy: 0.9050 - fusion_accuracy: 0.9371 - combined_accuracy: 0.9369 - opt_f1score: 0.9
150 - sar_f1score: 0.8853 - fusion_f1score: 0.9279 - combined_f1score: 0.9276 - val_
opt_loss: 0.1023 - val_sar_loss: 0.1385 - val_fusion_loss: 0.0906 - val_loss: 0.3314
- val_opt_accuracy: 0.9121 - val_sar_accuracy: 0.8499 - val_fusion_accuracy: 0.9172
- val_combined_accuracy: 0.9193 - val_opt_f1score: 0.8370 - val_sar_f1score: 0.7503
- val_fusion_f1score: 0.8529 - val_combined_f1score: 0.8547
Epoch 32/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0643 - sar_
loss: 0.0722 - fusion_loss: 0.0479 - loss: 0.1844 - opt_accuracy: 0.9326 - sar_accur
acy: 0.9087 - fusion_accuracy: 0.9377 - combined_accuracy: 0.9376 - opt_f1score: 0.9
150 - sar_f1score: 0.8930 - fusion_f1score: 0.9293 - combined_f1score: 0.9292 - val_
opt_loss: 0.1123 - val_sar_loss: 0.1555 - val_fusion_loss: 0.1070 - val_loss: 0.3749
- val_opt_accuracy: 0.9146 - val_sar_accuracy: 0.8884 - val_fusion_accuracy: 0.9159
- val_combined_accuracy: 0.9172 - val_opt_f1score: 0.8384 - val_sar_f1score: 0.7712
- val_fusion_f1score: 0.8421 - val_combined_f1score: 0.8452
Epoch 33/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0651 - sar_
loss: 0.0732 - fusion_loss: 0.0482 - loss: 0.1864 - opt_accuracy: 0.9333 - sar_accur
acy: 0.9086 - fusion_accuracy: 0.9383 - combined_accuracy: 0.9380 - opt_f1score: 0.9
147 - sar_f1score: 0.8923 - fusion_f1score: 0.9294 - combined_f1score: 0.9291 - val_
opt_loss: 0.0952 - val_sar_loss: 0.1572 - val_fusion_loss: 0.0894 - val_loss: 0.3418
- val_opt_accuracy: 0.9179 - val_sar_accuracy: 0.8830 - val_fusion_accuracy: 0.9183
- val_combined_accuracy: 0.9178 - val_opt_f1score: 0.8422 - val_sar_f1score: 0.7585
- val_fusion_f1score: 0.8519 - val_combined_f1score: 0.8506
Epoch 34/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0619 - sar_
loss: 0.0719 - fusion_loss: 0.0470 - loss: 0.1807 - opt_accuracy: 0.9349 - sar_accur
acy: 0.9088 - fusion_accuracy: 0.9394 - combined_accuracy: 0.9392 - opt_f1score: 0.9
182 - sar_f1score: 0.8930 - fusion_f1score: 0.9311 - combined_f1score: 0.9309 - val_
opt_loss: 0.0960 - val_sar_loss: 0.1617 - val_fusion_loss: 0.1031 - val_loss: 0.3608
- val_opt_accuracy: 0.9144 - val_sar_accuracy: 0.8902 - val_fusion_accuracy: 0.9149
- val_combined_accuracy: 0.9179 - val_opt_f1score: 0.8407 - val_sar_f1score: 0.7930
- val_fusion_f1score: 0.8437 - val_combined_f1score: 0.8493
Epoch 35/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0617 - sar_
loss: 0.0705 - fusion_loss: 0.0463 - loss: 0.1785 - opt_accuracy: 0.9346 - sar_accur
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acy: 0.9097 - fusion_accuracy: 0.9397 - combined_accuracy: 0.9393 - opt_f1score: 0.9
180 - sar_f1score: 0.8950 - fusion_f1score: 0.9317 - combined_f1score: 0.9315 - val_
opt_loss: 0.1107 - val_sar_loss: 0.1462 - val_fusion_loss: 0.1007 - val_loss: 0.3575
- val_opt_accuracy: 0.9037 - val_sar_accuracy: 0.8334 - val_fusion_accuracy: 0.9127
- val_combined_accuracy: 0.9150 - val_opt_f1score: 0.8273 - val_sar_f1score: 0.7300
- val_fusion_f1score: 0.8433 - val_combined_f1score: 0.8453
Epoch 36/200
330/330 [==============================] - 120s 364ms/step - opt_loss: 0.0593 - sar_
loss: 0.0682 - fusion_loss: 0.0448 - loss: 0.1723 - opt_accuracy: 0.9360 - sar_accur
acy: 0.9112 - fusion_accuracy: 0.9409 - combined_accuracy: 0.9406 - opt_f1score: 0.9
208 - sar_f1score: 0.8975 - fusion_f1score: 0.9336 - combined_f1score: 0.9335 - val_
opt_loss: 0.1086 - val_sar_loss: 0.1608 - val_fusion_loss: 0.1130 - val_loss: 0.3824
- val_opt_accuracy: 0.8994 - val_sar_accuracy: 0.8546 - val_fusion_accuracy: 0.9078
- val_combined_accuracy: 0.9109 - val_opt_f1score: 0.8228 - val_sar_f1score: 0.7571
- val_fusion_f1score: 0.8348 - val_combined_f1score: 0.8376
Epoch 37/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0570 - sar_
loss: 0.0649 - fusion_loss: 0.0430 - loss: 0.1650 - opt_accuracy: 0.9371 - sar_accur
acy: 0.9125 - fusion_accuracy: 0.9421 - combined_accuracy: 0.9418 - opt_f1score: 0.9
234 - sar_f1score: 0.9009 - fusion_f1score: 0.9356 - combined_f1score: 0.9355 - val_
opt_loss: 0.0945 - val_sar_loss: 0.1666 - val_fusion_loss: 0.0992 - val_loss: 0.3603
- val_opt_accuracy: 0.9214 - val_sar_accuracy: 0.8150 - val_fusion_accuracy: 0.9173
- val_combined_accuracy: 0.9189 - val_opt_f1score: 0.8570 - val_sar_f1score: 0.7005
- val_fusion_f1score: 0.8498 - val_combined_f1score: 0.8512
Epoch 38/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0568 - sar_
loss: 0.0672 - fusion_loss: 0.0434 - loss: 0.1675 - opt_accuracy: 0.9376 - sar_accur
acy: 0.9115 - fusion_accuracy: 0.9423 - combined_accuracy: 0.9420 - opt_f1score: 0.9
237 - sar_f1score: 0.8987 - fusion_f1score: 0.9355 - combined_f1score: 0.9354 - val_
opt_loss: 0.1131 - val_sar_loss: 0.1550 - val_fusion_loss: 0.1003 - val_loss: 0.3685
- val_opt_accuracy: 0.9140 - val_sar_accuracy: 0.8631 - val_fusion_accuracy: 0.9217
- val_combined_accuracy: 0.9215 - val_opt_f1score: 0.8394 - val_sar_f1score: 0.7502
- val_fusion_f1score: 0.8572 - val_combined_f1score: 0.8561
Epoch 39/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0573 - sar_
loss: 0.0670 - fusion_loss: 0.0436 - loss: 0.1679 - opt_accuracy: 0.9379 - sar_accur
acy: 0.9128 - fusion_accuracy: 0.9427 - combined_accuracy: 0.9422 - opt_f1score: 0.9
236 - sar_f1score: 0.8997 - fusion_f1score: 0.9357 - combined_f1score: 0.9355 - val_
opt_loss: 0.1089 - val_sar_loss: 0.1542 - val_fusion_loss: 0.1109 - val_loss: 0.3740
- val_opt_accuracy: 0.9141 - val_sar_accuracy: 0.8851 - val_fusion_accuracy: 0.9142
- val_combined_accuracy: 0.9167 - val_opt_f1score: 0.8305 - val_sar_f1score: 0.7898
- val_fusion_f1score: 0.8387 - val_combined_f1score: 0.8422
Epoch 40/200
330/330 [==============================] - 120s 363ms/step - opt_loss: 0.0552 - sar_
loss: 0.0629 - fusion_loss: 0.0418 - loss: 0.1600 - opt_accuracy: 0.9386 - sar_accur
acy: 0.9140 - fusion_accuracy: 0.9437 - combined_accuracy: 0.9435 - opt_f1score: 0.9
256 - sar_f1score: 0.9035 - fusion_f1score: 0.9377 - combined_f1score: 0.9377 - val_
opt_loss: 0.1022 - val_sar_loss: 0.1419 - val_fusion_loss: 0.0936 - val_loss: 0.3377
- val_opt_accuracy: 0.9138 - val_sar_accuracy: 0.8929 - val_fusion_accuracy: 0.9160
- val_combined_accuracy: 0.9181 - val_opt_f1score: 0.8467 - val_sar_f1score: 0.8037
- val_fusion_f1score: 0.8558 - val_combined_f1score: 0.8587
Epoch 41/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0560 - sar_
loss: 0.0654 - fusion_loss: 0.0425 - loss: 0.1638 - opt_accuracy: 0.9386 - sar_accur
acy: 0.9137 - fusion_accuracy: 0.9436 - combined_accuracy: 0.9433 - opt_f1score: 0.9
251 - sar_f1score: 0.9015 - fusion_f1score: 0.9371 - combined_f1score: 0.9370 - val_
opt_loss: 0.1007 - val_sar_loss: 0.1522 - val_fusion_loss: 0.1040 - val_loss: 0.3568
- val_opt_accuracy: 0.9211 - val_sar_accuracy: 0.8723 - val_fusion_accuracy: 0.9138
- val_combined_accuracy: 0.9176 - val_opt_f1score: 0.8492 - val_sar_f1score: 0.7749
- val_fusion_f1score: 0.8446 - val_combined_f1score: 0.8490
Epoch 42/200
330/330 [==============================] - 120s 362ms/step - opt_loss: 0.0547 - sar_
loss: 0.0612 - fusion_loss: 0.0411 - loss: 0.1570 - opt_accuracy: 0.9392 - sar_accur
acy: 0.9160 - fusion_accuracy: 0.9446 - combined_accuracy: 0.9443 - opt_f1score: 0.9
263 - sar_f1score: 0.9059 - fusion_f1score: 0.9386 - combined_f1score: 0.9386 - val_
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opt_loss: 0.1451 - val_sar_loss: 0.1635 - val_fusion_loss: 0.1335 - val_loss: 0.4421
- val_opt_accuracy: 0.9013 - val_sar_accuracy: 0.8622 - val_fusion_accuracy: 0.9117
- val_combined_accuracy: 0.9141 - val_opt_f1score: 0.7862 - val_sar_f1score: 0.7529
- val_fusion_f1score: 0.8191 - val_combined_f1score: 0.8235
Epoch 43/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0538 - sar_
loss: 0.0642 - fusion_loss: 0.0411 - loss: 0.1592 - opt_accuracy: 0.9398 - sar_accur
acy: 0.9152 - fusion_accuracy: 0.9449 - combined_accuracy: 0.9446 - opt_f1score: 0.9
275 - sar_f1score: 0.9032 - fusion_f1score: 0.9389 - combined_f1score: 0.9389 - val_
opt_loss: 0.1006 - val_sar_loss: 0.1617 - val_fusion_loss: 0.0932 - val_loss: 0.3555
- val_opt_accuracy: 0.9161 - val_sar_accuracy: 0.8236 - val_fusion_accuracy: 0.9109
- val_combined_accuracy: 0.9117 - val_opt_f1score: 0.8279 - val_sar_f1score: 0.7079
- val_fusion_f1score: 0.8410 - val_combined_f1score: 0.8379
Epoch 44/200
330/330 [==============================] - 119s 362ms/step - opt_loss: 0.0528 - sar_
loss: 0.0590 - fusion_loss: 0.0398 - loss: 0.1515 - opt_accuracy: 0.9404 - sar_accur
acy: 0.9177 - fusion_accuracy: 0.9458 - combined_accuracy: 0.9456 - opt_f1score: 0.9
287 - sar_f1score: 0.9088 - fusion_f1score: 0.9404 - combined_f1score: 0.9404 - val_
opt_loss: 0.1052 - val_sar_loss: 0.2203 - val_fusion_loss: 0.1279 - val_loss: 0.4534
- val_opt_accuracy: 0.9185 - val_sar_accuracy: 0.8916 - val_fusion_accuracy: 0.9176
- val_combined_accuracy: 0.9194 - val_opt_f1score: 0.8458 - val_sar_f1score: 0.7841
- val_fusion_f1score: 0.8450 - val_combined_f1score: 0.8504
Epoch 45/200
330/330 [==============================] - 119s 362ms/step - opt_loss: 0.0518 - sar_
loss: 0.0595 - fusion_loss: 0.0393 - loss: 0.1507 - opt_accuracy: 0.9410 - sar_accur
acy: 0.9175 - fusion_accuracy: 0.9464 - combined_accuracy: 0.9462 - opt_f1score: 0.9
295 - sar_f1score: 0.9082 - fusion_f1score: 0.9411 - combined_f1score: 0.9411 - val_
opt_loss: 0.1086 - val_sar_loss: 0.2332 - val_fusion_loss: 0.1379 - val_loss: 0.4798
- val_opt_accuracy: 0.9183 - val_sar_accuracy: 0.8775 - val_fusion_accuracy: 0.9145
- val_combined_accuracy: 0.9171 - val_opt_f1score: 0.8397 - val_sar_f1score: 0.7439
- val_fusion_f1score: 0.8238 - val_combined_f1score: 0.8303
Epoch 46/200
330/330 [==============================] - 121s 366ms/step - opt_loss: 0.0511 - sar_
loss: 0.0587 - fusion_loss: 0.0389 - loss: 0.1488 - opt_accuracy: 0.9416 - sar_accur
acy: 0.9183 - fusion_accuracy: 0.9469 - combined_accuracy: 0.9467 - opt_f1score: 0.9
306 - sar_f1score: 0.9094 - fusion_f1score: 0.9417 - combined_f1score: 0.9417 - val_
opt_loss: 0.0982 - val_sar_loss: 0.2188 - val_fusion_loss: 0.1256 - val_loss: 0.4426
- val_opt_accuracy: 0.9165 - val_sar_accuracy: 0.8902 - val_fusion_accuracy: 0.9105
- val_combined_accuracy: 0.9136 - val_opt_f1score: 0.8543 - val_sar_f1score: 0.7774
- val_fusion_f1score: 0.8403 - val_combined_f1score: 0.8450
Epoch 47/200
330/330 [==============================] - 121s 368ms/step - opt_loss: 0.0510 - sar_
loss: 0.0579 - fusion_loss: 0.0387 - loss: 0.1476 - opt_accuracy: 0.9420 - sar_accur
acy: 0.9197 - fusion_accuracy: 0.9474 - combined_accuracy: 0.9473 - opt_f1score: 0.9
309 - sar_f1score: 0.9107 - fusion_f1score: 0.9421 - combined_f1score: 0.9423 - val_
opt_loss: 0.0940 - val_sar_loss: 0.1752 - val_fusion_loss: 0.1021 - val_loss: 0.3714
- val_opt_accuracy: 0.9226 - val_sar_accuracy: 0.7980 - val_fusion_accuracy: 0.9198
- val_combined_accuracy: 0.9203 - val_opt_f1score: 0.8606 - val_sar_f1score: 0.6983
- val_fusion_f1score: 0.8568 - val_combined_f1score: 0.8573
Epoch 48/200
330/330 [==============================] - 119s 362ms/step - opt_loss: 0.0508 - sar_
loss: 0.0597 - fusion_loss: 0.0387 - loss: 0.1492 - opt_accuracy: 0.9418 - sar_accur
acy: 0.9176 - fusion_accuracy: 0.9472 - combined_accuracy: 0.9468 - opt_f1score: 0.9
310 - sar_f1score: 0.9082 - fusion_f1score: 0.9420 - combined_f1score: 0.9420 - val_
opt_loss: 0.1034 - val_sar_loss: 0.1583 - val_fusion_loss: 0.1047 - val_loss: 0.3664
- val_opt_accuracy: 0.9207 - val_sar_accuracy: 0.8924 - val_fusion_accuracy: 0.9217
- val_combined_accuracy: 0.9222 - val_opt_f1score: 0.8509 - val_sar_f1score: 0.8009
- val_fusion_f1score: 0.8534 - val_combined_f1score: 0.8554
Epoch 49/200
330/330 [==============================] - 119s 362ms/step - opt_loss: 0.0486 - sar_
loss: 0.0548 - fusion_loss: 0.0369 - loss: 0.1403 - opt_accuracy: 0.9438 - sar_accur
acy: 0.9216 - fusion_accuracy: 0.9493 - combined_accuracy: 0.9490 - opt_f1score: 0.9
339 - sar_f1score: 0.9142 - fusion_f1score: 0.9447 - combined_f1score: 0.9447 - val_
opt_loss: 0.1192 - val_sar_loss: 0.1792 - val_fusion_loss: 0.1101 - val_loss: 0.4085
- val_opt_accuracy: 0.9155 - val_sar_accuracy: 0.7722 - val_fusion_accuracy: 0.9192
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- val_combined_accuracy: 0.9199 - val_opt_f1score: 0.8499 - val_sar_f1score: 0.6479
- val_fusion_f1score: 0.8544 - val_combined_f1score: 0.8539
Epoch 50/200
330/330 [==============================] - 121s 367ms/step - opt_loss: 0.0486 - sar_
loss: 0.0551 - fusion_loss: 0.0369 - loss: 0.1406 - opt_accuracy: 0.9433 - sar_accur
acy: 0.9213 - fusion_accuracy: 0.9489 - combined_accuracy: 0.9487 - opt_f1score: 0.9
334 - sar_f1score: 0.9135 - fusion_f1score: 0.9444 - combined_f1score: 0.9444 - val_
opt_loss: 0.1147 - val_sar_loss: 0.1982 - val_fusion_loss: 0.1159 - val_loss: 0.4287
- val_opt_accuracy: 0.9171 - val_sar_accuracy: 0.7870 - val_fusion_accuracy: 0.9137
- val_combined_accuracy: 0.9154 - val_opt_f1score: 0.8470 - val_sar_f1score: 0.6712
- val_fusion_f1score: 0.8459 - val_combined_f1score: 0.8472
Epoch 51/200
330/330 [==============================] - 120s 364ms/step - opt_loss: 0.0480 - sar_
loss: 0.0542 - fusion_loss: 0.0365 - loss: 0.1387 - opt_accuracy: 0.9442 - sar_accur
acy: 0.9223 - fusion_accuracy: 0.9498 - combined_accuracy: 0.9496 - opt_f1score: 0.9
345 - sar_f1score: 0.9150 - fusion_f1score: 0.9453 - combined_f1score: 0.9454 - val_
opt_loss: 0.1065 - val_sar_loss: 0.2534 - val_fusion_loss: 0.1405 - val_loss: 0.5003
- val_opt_accuracy: 0.9164 - val_sar_accuracy: 0.8899 - val_fusion_accuracy: 0.9158
- val_combined_accuracy: 0.9170 - val_opt_f1score: 0.8533 - val_sar_f1score: 0.7364
- val_fusion_f1score: 0.8317 - val_combined_f1score: 0.8363
Epoch 52/200
330/330 [==============================] - 120s 363ms/step - opt_loss: 0.0473 - sar_
loss: 0.0530 - fusion_loss: 0.0360 - loss: 0.1364 - opt_accuracy: 0.9447 - sar_accur
acy: 0.9232 - fusion_accuracy: 0.9505 - combined_accuracy: 0.9503 - opt_f1score: 0.9
354 - sar_f1score: 0.9164 - fusion_f1score: 0.9462 - combined_f1score: 0.9462 - val_
opt_loss: 0.0942 - val_sar_loss: 0.2111 - val_fusion_loss: 0.1060 - val_loss: 0.4113
- val_opt_accuracy: 0.9254 - val_sar_accuracy: 0.7525 - val_fusion_accuracy: 0.9099
- val_combined_accuracy: 0.9112 - val_opt_f1score: 0.8646 - val_sar_f1score: 0.6276
- val_fusion_f1score: 0.8453 - val_combined_f1score: 0.8451
Epoch 53/200
330/330 [==============================] - 120s 362ms/step - opt_loss: 0.0478 - sar_
loss: 0.0539 - fusion_loss: 0.0363 - loss: 0.1380 - opt_accuracy: 0.9447 - sar_accur
acy: 0.9224 - fusion_accuracy: 0.9504 - combined_accuracy: 0.9501 - opt_f1score: 0.9
350 - sar_f1score: 0.9151 - fusion_f1score: 0.9458 - combined_f1score: 0.9458 - val_
opt_loss: 0.1044 - val_sar_loss: 0.1765 - val_fusion_loss: 0.1011 - val_loss: 0.3820
- val_opt_accuracy: 0.9226 - val_sar_accuracy: 0.8618 - val_fusion_accuracy: 0.9213
- val_combined_accuracy: 0.9234 - val_opt_f1score: 0.8570 - val_sar_f1score: 0.7690
- val_fusion_f1score: 0.8598 - val_combined_f1score: 0.8617
Epoch 54/200
330/330 [==============================] - 119s 362ms/step - opt_loss: 0.0506 - sar_
loss: 0.0663 - fusion_loss: 0.0391 - loss: 0.1560 - opt_accuracy: 0.9423 - sar_accur
acy: 0.9101 - fusion_accuracy: 0.9472 - combined_accuracy: 0.9471 - opt_f1score: 0.9
314 - sar_f1score: 0.8984 - fusion_f1score: 0.9418 - combined_f1score: 0.9419 - val_
opt_loss: 0.1054 - val_sar_loss: 0.1548 - val_fusion_loss: 0.0924 - val_loss: 0.3525
- val_opt_accuracy: 0.9209 - val_sar_accuracy: 0.8895 - val_fusion_accuracy: 0.9244
- val_combined_accuracy: 0.9242 - val_opt_f1score: 0.8640 - val_sar_f1score: 0.7856
- val_fusion_f1score: 0.8709 - val_combined_f1score: 0.8710
Epoch 55/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0463 - sar_
loss: 0.0531 - fusion_loss: 0.0355 - loss: 0.1349 - opt_accuracy: 0.9453 - sar_accur
acy: 0.9223 - fusion_accuracy: 0.9508 - combined_accuracy: 0.9506 - opt_f1score: 0.9
365 - sar_f1score: 0.9157 - fusion_f1score: 0.9467 - combined_f1score: 0.9468 - val_
opt_loss: 0.1100 - val_sar_loss: 0.1606 - val_fusion_loss: 0.1004 - val_loss: 0.3710
- val_opt_accuracy: 0.9225 - val_sar_accuracy: 0.8906 - val_fusion_accuracy: 0.9244
- val_combined_accuracy: 0.9247 - val_opt_f1score: 0.8608 - val_sar_f1score: 0.8050
- val_fusion_f1score: 0.8684 - val_combined_f1score: 0.8703
Epoch 56/200
330/330 [==============================] - 119s 362ms/step - opt_loss: 0.0445 - sar_
loss: 0.0507 - fusion_loss: 0.0341 - loss: 0.1293 - opt_accuracy: 0.9466 - sar_accur
acy: 0.9240 - fusion_accuracy: 0.9523 - combined_accuracy: 0.9520 - opt_f1score: 0.9
386 - sar_f1score: 0.9184 - fusion_f1score: 0.9486 - combined_f1score: 0.9486 - val_
opt_loss: 0.1017 - val_sar_loss: 0.1916 - val_fusion_loss: 0.1097 - val_loss: 0.4030
- val_opt_accuracy: 0.9243 - val_sar_accuracy: 0.7898 - val_fusion_accuracy: 0.9168
- val_combined_accuracy: 0.9169 - val_opt_f1score: 0.8586 - val_sar_f1score: 0.6843
- val_fusion_f1score: 0.8518 - val_combined_f1score: 0.8501
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Epoch 57/200
330/330 [==============================] - 121s 368ms/step - opt_loss: 0.0453 - sar_
loss: 0.0505 - fusion_loss: 0.0344 - loss: 0.1302 - opt_accuracy: 0.9463 - sar_accur
acy: 0.9247 - fusion_accuracy: 0.9521 - combined_accuracy: 0.9519 - opt_f1score: 0.9
378 - sar_f1score: 0.9190 - fusion_f1score: 0.9483 - combined_f1score: 0.9483 - val_
opt_loss: 0.1044 - val_sar_loss: 0.1642 - val_fusion_loss: 0.0988 - val_loss: 0.3674
- val_opt_accuracy: 0.9228 - val_sar_accuracy: 0.8823 - val_fusion_accuracy: 0.9238
- val_combined_accuracy: 0.9245 - val_opt_f1score: 0.8612 - val_sar_f1score: 0.7683
- val_fusion_f1score: 0.8630 - val_combined_f1score: 0.8629
Epoch 58/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0435 - sar_
loss: 0.0488 - fusion_loss: 0.0333 - loss: 0.1256 - opt_accuracy: 0.9479 - sar_accur
acy: 0.9267 - fusion_accuracy: 0.9536 - combined_accuracy: 0.9533 - opt_f1score: 0.9
401 - sar_f1score: 0.9215 - fusion_f1score: 0.9501 - combined_f1score: 0.9501 - val_
opt_loss: 0.1076 - val_sar_loss: 0.1649 - val_fusion_loss: 0.1021 - val_loss: 0.3746
- val_opt_accuracy: 0.9252 - val_sar_accuracy: 0.8787 - val_fusion_accuracy: 0.9262
- val_combined_accuracy: 0.9270 - val_opt_f1score: 0.8697 - val_sar_f1score: 0.7764
- val_fusion_f1score: 0.8698 - val_combined_f1score: 0.8698
Epoch 59/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0439 - sar_
loss: 0.0486 - fusion_loss: 0.0333 - loss: 0.1258 - opt_accuracy: 0.9475 - sar_accur
acy: 0.9278 - fusion_accuracy: 0.9538 - combined_accuracy: 0.9537 - opt_f1score: 0.9
396 - sar_f1score: 0.9224 - fusion_f1score: 0.9503 - combined_f1score: 0.9504 - val_
opt_loss: 0.0996 - val_sar_loss: 0.2039 - val_fusion_loss: 0.1185 - val_loss: 0.4219
- val_opt_accuracy: 0.9272 - val_sar_accuracy: 0.8995 - val_fusion_accuracy: 0.9275
- val_combined_accuracy: 0.9290 - val_opt_f1score: 0.8622 - val_sar_f1score: 0.8074
- val_fusion_f1score: 0.8602 - val_combined_f1score: 0.8633
Epoch 60/200
330/330 [==============================] - 120s 365ms/step - opt_loss: 0.0449 - sar_
loss: 0.0516 - fusion_loss: 0.0342 - loss: 0.1308 - opt_accuracy: 0.9473 - sar_accur
acy: 0.9263 - fusion_accuracy: 0.9532 - combined_accuracy: 0.9531 - opt_f1score: 0.9
388 - sar_f1score: 0.9195 - fusion_f1score: 0.9493 - combined_f1score: 0.9493 - val_
opt_loss: 0.0996 - val_sar_loss: 0.1563 - val_fusion_loss: 0.0956 - val_loss: 0.3515
- val_opt_accuracy: 0.9267 - val_sar_accuracy: 0.8899 - val_fusion_accuracy: 0.9260
- val_combined_accuracy: 0.9276 - val_opt_f1score: 0.8593 - val_sar_f1score: 0.7962
- val_fusion_f1score: 0.8640 - val_combined_f1score: 0.8669
Epoch 61/200
330/330 [==============================] - 120s 363ms/step - opt_loss: 0.0449 - sar_
loss: 0.0498 - fusion_loss: 0.0339 - loss: 0.1286 - opt_accuracy: 0.9469 - sar_accur
acy: 0.9271 - fusion_accuracy: 0.9533 - combined_accuracy: 0.9531 - opt_f1score: 0.9
385 - sar_f1score: 0.9212 - fusion_f1score: 0.9495 - combined_f1score: 0.9496 - val_
opt_loss: 0.1059 - val_sar_loss: 0.2702 - val_fusion_loss: 0.1463 - val_loss: 0.5224
- val_opt_accuracy: 0.9258 - val_sar_accuracy: 0.8835 - val_fusion_accuracy: 0.9213
- val_combined_accuracy: 0.9236 - val_opt_f1score: 0.8681 - val_sar_f1score: 0.7567
- val_fusion_f1score: 0.8435 - val_combined_f1score: 0.8458
Epoch 62/200
330/330 [==============================] - 120s 364ms/step - opt_loss: 0.0427 - sar_
loss: 0.0486 - fusion_loss: 0.0327 - loss: 0.1241 - opt_accuracy: 0.9489 - sar_accur
acy: 0.9283 - fusion_accuracy: 0.9549 - combined_accuracy: 0.9547 - opt_f1score: 0.9
413 - sar_f1score: 0.9227 - fusion_f1score: 0.9515 - combined_f1score: 0.9514 - val_
opt_loss: 0.1081 - val_sar_loss: 0.1950 - val_fusion_loss: 0.1180 - val_loss: 0.4211
- val_opt_accuracy: 0.9170 - val_sar_accuracy: 0.7714 - val_fusion_accuracy: 0.8754
- val_combined_accuracy: 0.8890 - val_opt_f1score: 0.8481 - val_sar_f1score: 0.6677
- val_fusion_f1score: 0.8127 - val_combined_f1score: 0.8244
Epoch 63/200
330/330 [==============================] - 119s 362ms/step - opt_loss: 0.0434 - sar_
loss: 0.0467 - fusion_loss: 0.0322 - loss: 0.1222 - opt_accuracy: 0.9486 - sar_accur
acy: 0.9294 - fusion_accuracy: 0.9552 - combined_accuracy: 0.9551 - opt_f1score: 0.9
407 - sar_f1score: 0.9249 - fusion_f1score: 0.9520 - combined_f1score: 0.9520 - val_
opt_loss: 0.1273 - val_sar_loss: 0.2285 - val_fusion_loss: 0.1353 - val_loss: 0.4911
- val_opt_accuracy: 0.9027 - val_sar_accuracy: 0.8985 - val_fusion_accuracy: 0.9131
- val_combined_accuracy: 0.9152 - val_opt_f1score: 0.8372 - val_sar_f1score: 0.7967
- val_fusion_f1score: 0.8446 - val_combined_f1score: 0.8476
Epoch 64/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0435 - sar_
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loss: 0.0484 - fusion_loss: 0.0329 - loss: 0.1248 - opt_accuracy: 0.9482 - sar_accur
acy: 0.9282 - fusion_accuracy: 0.9545 - combined_accuracy: 0.9544 - opt_f1score: 0.9
403 - sar_f1score: 0.9228 - fusion_f1score: 0.9509 - combined_f1score: 0.9510 - val_
opt_loss: 0.1157 - val_sar_loss: 0.1954 - val_fusion_loss: 0.1250 - val_loss: 0.4361
- val_opt_accuracy: 0.9204 - val_sar_accuracy: 0.8735 - val_fusion_accuracy: 0.9225
- val_combined_accuracy: 0.9245 - val_opt_f1score: 0.8516 - val_sar_f1score: 0.7819
- val_fusion_f1score: 0.8532 - val_combined_f1score: 0.8541
Epoch 65/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0421 - sar_
loss: 0.0478 - fusion_loss: 0.0323 - loss: 0.1221 - opt_accuracy: 0.9493 - sar_accur
acy: 0.9293 - fusion_accuracy: 0.9555 - combined_accuracy: 0.9552 - opt_f1score: 0.9
420 - sar_f1score: 0.9239 - fusion_f1score: 0.9521 - combined_f1score: 0.9520 - val_
opt_loss: 0.1168 - val_sar_loss: 0.2104 - val_fusion_loss: 0.1261 - val_loss: 0.4533
- val_opt_accuracy: 0.9209 - val_sar_accuracy: 0.8255 - val_fusion_accuracy: 0.9233
- val_combined_accuracy: 0.9243 - val_opt_f1score: 0.8592 - val_sar_f1score: 0.7303
- val_fusion_f1score: 0.8579 - val_combined_f1score: 0.8595
Epoch 66/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0411 - sar_
loss: 0.0462 - fusion_loss: 0.0315 - loss: 0.1187 - opt_accuracy: 0.9500 - sar_accur
acy: 0.9313 - fusion_accuracy: 0.9562 - combined_accuracy: 0.9560 - opt_f1score: 0.9
431 - sar_f1score: 0.9266 - fusion_f1score: 0.9531 - combined_f1score: 0.9531 - val_
opt_loss: 0.1023 - val_sar_loss: 0.2345 - val_fusion_loss: 0.1198 - val_loss: 0.4567
- val_opt_accuracy: 0.9239 - val_sar_accuracy: 0.7130 - val_fusion_accuracy: 0.8949
- val_combined_accuracy: 0.8954 - val_opt_f1score: 0.8637 - val_sar_f1score: 0.5668
- val_fusion_f1score: 0.8337 - val_combined_f1score: 0.8322
Epoch 67/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0402 - sar_
loss: 0.0452 - fusion_loss: 0.0308 - loss: 0.1161 - opt_accuracy: 0.9510 - sar_accur
acy: 0.9321 - fusion_accuracy: 0.9572 - combined_accuracy: 0.9571 - opt_f1score: 0.9
443 - sar_f1score: 0.9276 - fusion_f1score: 0.9543 - combined_f1score: 0.9542 - val_
opt_loss: 0.1227 - val_sar_loss: 0.2435 - val_fusion_loss: 0.1015 - val_loss: 0.4677
- val_opt_accuracy: 0.9205 - val_sar_accuracy: 0.8545 - val_fusion_accuracy: 0.9257
- val_combined_accuracy: 0.9260 - val_opt_f1score: 0.8530 - val_sar_f1score: 0.6985
- val_fusion_f1score: 0.8681 - val_combined_f1score: 0.8678
Epoch 68/200
330/330 [==============================] - 120s 364ms/step - opt_loss: 0.0404 - sar_
loss: 0.0454 - fusion_loss: 0.0311 - loss: 0.1169 - opt_accuracy: 0.9512 - sar_accur
acy: 0.9317 - fusion_accuracy: 0.9573 - combined_accuracy: 0.9571 - opt_f1score: 0.9
444 - sar_f1score: 0.9271 - fusion_f1score: 0.9542 - combined_f1score: 0.9542 - val_
opt_loss: 0.0962 - val_sar_loss: 0.1779 - val_fusion_loss: 0.0935 - val_loss: 0.3676
- val_opt_accuracy: 0.9301 - val_sar_accuracy: 0.9018 - val_fusion_accuracy: 0.9284
- val_combined_accuracy: 0.9289 - val_opt_f1score: 0.8722 - val_sar_f1score: 0.8189
- val_fusion_f1score: 0.8749 - val_combined_f1score: 0.8767
Epoch 69/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0401 - sar_
loss: 0.0447 - fusion_loss: 0.0305 - loss: 0.1153 - opt_accuracy: 0.9518 - sar_accur
acy: 0.9331 - fusion_accuracy: 0.9580 - combined_accuracy: 0.9578 - opt_f1score: 0.9
449 - sar_f1score: 0.9286 - fusion_f1score: 0.9549 - combined_f1score: 0.9549 - val_
opt_loss: 0.1119 - val_sar_loss: 0.1859 - val_fusion_loss: 0.1129 - val_loss: 0.4108
- val_opt_accuracy: 0.9244 - val_sar_accuracy: 0.8755 - val_fusion_accuracy: 0.9217
- val_combined_accuracy: 0.9226 - val_opt_f1score: 0.8587 - val_sar_f1score: 0.7873
- val_fusion_f1score: 0.8625 - val_combined_f1score: 0.8621
Epoch 70/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0412 - sar_
loss: 0.0458 - fusion_loss: 0.0313 - loss: 0.1182 - opt_accuracy: 0.9508 - sar_accur
acy: 0.9316 - fusion_accuracy: 0.9571 - combined_accuracy: 0.9570 - opt_f1score: 0.9
436 - sar_f1score: 0.9269 - fusion_f1score: 0.9539 - combined_f1score: 0.9539 - val_
opt_loss: 0.1099 - val_sar_loss: 0.2458 - val_fusion_loss: 0.1445 - val_loss: 0.5003
- val_opt_accuracy: 0.9290 - val_sar_accuracy: 0.8932 - val_fusion_accuracy: 0.9233
- val_combined_accuracy: 0.9243 - val_opt_f1score: 0.8692 - val_sar_f1score: 0.7922
- val_fusion_f1score: 0.8527 - val_combined_f1score: 0.8563
Epoch 71/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0405 - sar_
loss: 0.0444 - fusion_loss: 0.0304 - loss: 0.1153 - opt_accuracy: 0.9514 - sar_accur
acy: 0.9333 - fusion_accuracy: 0.9580 - combined_accuracy: 0.9578 - opt_f1score: 0.9
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444 - sar_f1score: 0.9290 - fusion_f1score: 0.9551 - combined_f1score: 0.9550 - val_
opt_loss: 0.1077 - val_sar_loss: 0.2036 - val_fusion_loss: 0.1121 - val_loss: 0.4234
- val_opt_accuracy: 0.9263 - val_sar_accuracy: 0.8132 - val_fusion_accuracy: 0.9018
- val_combined_accuracy: 0.9081 - val_opt_f1score: 0.8681 - val_sar_f1score: 0.7261
- val_fusion_f1score: 0.8459 - val_combined_f1score: 0.8512
Epoch 72/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0397 - sar_
loss: 0.0455 - fusion_loss: 0.0304 - loss: 0.1157 - opt_accuracy: 0.9518 - sar_accur
acy: 0.9327 - fusion_accuracy: 0.9581 - combined_accuracy: 0.9580 - opt_f1score: 0.9
452 - sar_f1score: 0.9276 - fusion_f1score: 0.9551 - combined_f1score: 0.9551 - val_
opt_loss: 0.0955 - val_sar_loss: 0.2734 - val_fusion_loss: 0.1447 - val_loss: 0.5135
- val_opt_accuracy: 0.9262 - val_sar_accuracy: 0.8738 - val_fusion_accuracy: 0.9129
- val_combined_accuracy: 0.9198 - val_opt_f1score: 0.8656 - val_sar_f1score: 0.7501
- val_fusion_f1score: 0.8362 - val_combined_f1score: 0.8427
Epoch 73/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0393 - sar_
loss: 0.0433 - fusion_loss: 0.0298 - loss: 0.1124 - opt_accuracy: 0.9526 - sar_accur
acy: 0.9349 - fusion_accuracy: 0.9590 - combined_accuracy: 0.9588 - opt_f1score: 0.9
461 - sar_f1score: 0.9309 - fusion_f1score: 0.9562 - combined_f1score: 0.9561 - val_
opt_loss: 0.1151 - val_sar_loss: 0.2116 - val_fusion_loss: 0.1228 - val_loss: 0.4495
- val_opt_accuracy: 0.9257 - val_sar_accuracy: 0.8922 - val_fusion_accuracy: 0.9217
- val_combined_accuracy: 0.9212 - val_opt_f1score: 0.8667 - val_sar_f1score: 0.8055
- val_fusion_f1score: 0.8642 - val_combined_f1score: 0.8651
Epoch 74/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0383 - sar_
loss: 0.0426 - fusion_loss: 0.0292 - loss: 0.1101 - opt_accuracy: 0.9532 - sar_accur
acy: 0.9356 - fusion_accuracy: 0.9595 - combined_accuracy: 0.9593 - opt_f1score: 0.9
472 - sar_f1score: 0.9317 - fusion_f1score: 0.9569 - combined_f1score: 0.9568 - val_
opt_loss: 0.1153 - val_sar_loss: 0.1959 - val_fusion_loss: 0.1075 - val_loss: 0.4186
- val_opt_accuracy: 0.9237 - val_sar_accuracy: 0.8913 - val_fusion_accuracy: 0.9253
- val_combined_accuracy: 0.9278 - val_opt_f1score: 0.8593 - val_sar_f1score: 0.7779
- val_fusion_f1score: 0.8690 - val_combined_f1score: 0.8698
Epoch 75/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0385 - sar_
loss: 0.0425 - fusion_loss: 0.0294 - loss: 0.1104 - opt_accuracy: 0.9529 - sar_accur
acy: 0.9351 - fusion_accuracy: 0.9596 - combined_accuracy: 0.9594 - opt_f1score: 0.9
467 - sar_f1score: 0.9314 - fusion_f1score: 0.9568 - combined_f1score: 0.9567 - val_
opt_loss: 0.1095 - val_sar_loss: 0.2032 - val_fusion_loss: 0.1144 - val_loss: 0.4271
- val_opt_accuracy: 0.9263 - val_sar_accuracy: 0.8995 - val_fusion_accuracy: 0.9256
- val_combined_accuracy: 0.9274 - val_opt_f1score: 0.8605 - val_sar_f1score: 0.8186
- val_fusion_f1score: 0.8663 - val_combined_f1score: 0.8690
Epoch 76/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0388 - sar_
loss: 0.0438 - fusion_loss: 0.0297 - loss: 0.1122 - opt_accuracy: 0.9533 - sar_accur
acy: 0.9343 - fusion_accuracy: 0.9596 - combined_accuracy: 0.9594 - opt_f1score: 0.9
468 - sar_f1score: 0.9300 - fusion_f1score: 0.9567 - combined_f1score: 0.9566 - val_
opt_loss: 0.1076 - val_sar_loss: 2.9326 - val_fusion_loss: 0.3090 - val_loss: 3.3492
- val_opt_accuracy: 0.9203 - val_sar_accuracy: 0.5833 - val_fusion_accuracy: 0.8857
- val_combined_accuracy: 0.8872 - val_opt_f1score: 0.8471 - val_sar_f1score: 0.2640
- val_fusion_f1score: 0.7298 - val_combined_f1score: 0.7229
Epoch 77/200
330/330 [==============================] - 119s 361ms/step - opt_loss: 0.0396 - sar_
loss: 0.0441 - fusion_loss: 0.0297 - loss: 0.1134 - opt_accuracy: 0.9530 - sar_accur
acy: 0.9350 - fusion_accuracy: 0.9597 - combined_accuracy: 0.9596 - opt_f1score: 0.9
461 - sar_f1score: 0.9304 - fusion_f1score: 0.9568 - combined_f1score: 0.9567 - val_
opt_loss: 0.1111 - val_sar_loss: 0.2142 - val_fusion_loss: 0.1176 - val_loss: 0.4428
- val_opt_accuracy: 0.9260 - val_sar_accuracy: 0.8469 - val_fusion_accuracy: 0.9206
- val_combined_accuracy: 0.9213 - val_opt_f1score: 0.8582 - val_sar_f1score: 0.7578
- val_fusion_f1score: 0.8561 - val_combined_f1score: 0.8556
Epoch 78/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0372 - sar_
loss: 0.0415 - fusion_loss: 0.0284 - loss: 0.1071 - opt_accuracy: 0.9545 - sar_accur
acy: 0.9367 - fusion_accuracy: 0.9609 - combined_accuracy: 0.9608 - opt_f1score: 0.9
487 - sar_f1score: 0.9332 - fusion_f1score: 0.9585 - combined_f1score: 0.9584 - val_
opt_loss: 0.1292 - val_sar_loss: 0.9337 - val_fusion_loss: 0.5604 - val_loss: 1.6233
```

```
- val_opt_accuracy: 0.9246 - val_sar_accuracy: 0.7238 - val_fusion_accuracy: 0.8256
- val_combined_accuracy: 0.8270 - val_opt_f1score: 0.8552 - val_sar_f1score: 0.4568
- val_fusion_f1score: 0.6581 - val_combined_f1score: 0.6753
Epoch 79/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0392 - sar_
loss: 0.0460 - fusion_loss: 0.0299 - loss: 0.1151 - opt_accuracy: 0.9531 - sar_accur
acy: 0.9325 - fusion_accuracy: 0.9592 - combined_accuracy: 0.9591 - opt_f1score: 0.9
464 - sar_f1score: 0.9274 - fusion_f1score: 0.9563 - combined_f1score: 0.9563 - val_
opt_loss: 0.1111 - val_sar_loss: 0.3045 - val_fusion_loss: 0.1635 - val_loss: 0.5792
- val_opt_accuracy: 0.9255 - val_sar_accuracy: 0.8370 - val_fusion_accuracy: 0.8984
- val_combined_accuracy: 0.8985 - val_opt_f1score: 0.8601 - val_sar_f1score: 0.7588
- val_fusion_f1score: 0.8362 - val_combined_f1score: 0.8369
Epoch 80/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0368 - sar_
loss: 0.0411 - fusion_loss: 0.0282 - loss: 0.1061 - opt_accuracy: 0.9548 - sar_accur
acy: 0.9367 - fusion_accuracy: 0.9612 - combined_accuracy: 0.9611 - opt_f1score: 0.9
491 - sar_f1score: 0.9334 - fusion_f1score: 0.9588 - combined_f1score: 0.9588 - val_
opt_loss: 0.1193 - val_sar_loss: 0.1934 - val_fusion_loss: 0.1149 - val_loss: 0.4276
- val_opt_accuracy: 0.9244 - val_sar_accuracy: 0.8331 - val_fusion_accuracy: 0.9306
- val_combined_accuracy: 0.9316 - val_opt_f1score: 0.8636 - val_sar_f1score: 0.7475
- val_fusion_f1score: 0.8706 - val_combined_f1score: 0.8721
Epoch 81/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0369 - sar_
loss: 0.0408 - fusion_loss: 0.0280 - loss: 0.1057 - opt_accuracy: 0.9549 - sar_accur
acy: 0.9374 - fusion_accuracy: 0.9615 - combined_accuracy: 0.9614 - opt_f1score: 0.9
492 - sar_f1score: 0.9341 - fusion_f1score: 0.9592 - combined_f1score: 0.9591 - val_
opt_loss: 0.1101 - val_sar_loss: 0.2567 - val_fusion_loss: 0.1342 - val_loss: 0.5009
- val_opt_accuracy: 0.9307 - val_sar_accuracy: 0.8491 - val_fusion_accuracy: 0.9080
- val_combined_accuracy: 0.9097 - val_opt_f1score: 0.8705 - val_sar_f1score: 0.7895
- val_fusion_f1score: 0.8583 - val_combined_f1score: 0.8614
Epoch 82/200
330/330 [==============================] - 119s 360ms/step - opt_loss: 0.0358 - sar_
loss: 0.0400 - fusion_loss: 0.0275 - loss: 0.1033 - opt_accuracy: 0.9562 - sar_accur
acy: 0.9382 - fusion_accuracy: 0.9625 - combined_accuracy: 0.9623 - opt_f1score: 0.9
508 - sar_f1score: 0.9352 - fusion_f1score: 0.9602 - combined_f1score: 0.9601 - val_
opt_loss: 0.1036 - val_sar_loss: 0.1893 - val_fusion_loss: 0.1066 - val_loss: 0.3995
- val_opt_accuracy: 0.9271 - val_sar_accuracy: 0.8884 - val_fusion_accuracy: 0.9165
- val_combined_accuracy: 0.9202 - val_opt_f1score: 0.8753 - val_sar_f1score: 0.8118
- val_fusion_f1score: 0.8716 - val_combined_f1score: 0.8747
Epoch 83/200
330/330 [==============================] - 118s 358ms/step - opt_loss: 0.0364 - sar_
loss: 0.0400 - fusion_loss: 0.0276 - loss: 0.1040 - opt_accuracy: 0.9561 - sar_accur
acy: 0.9388 - fusion_accuracy: 0.9626 - combined_accuracy: 0.9624 - opt_f1score: 0.9
503 - sar_f1score: 0.9355 - fusion_f1score: 0.9602 - combined_f1score: 0.9601 - val_
opt_loss: 0.1215 - val_sar_loss: 0.2647 - val_fusion_loss: 0.1436 - val_loss: 0.5298
- val_opt_accuracy: 0.9304 - val_sar_accuracy: 0.8398 - val_fusion_accuracy: 0.9046
- val_combined_accuracy: 0.9040 - val_opt_f1score: 0.8688 - val_sar_f1score: 0.7828
- val_fusion_f1score: 0.8583 - val_combined_f1score: 0.8586
```

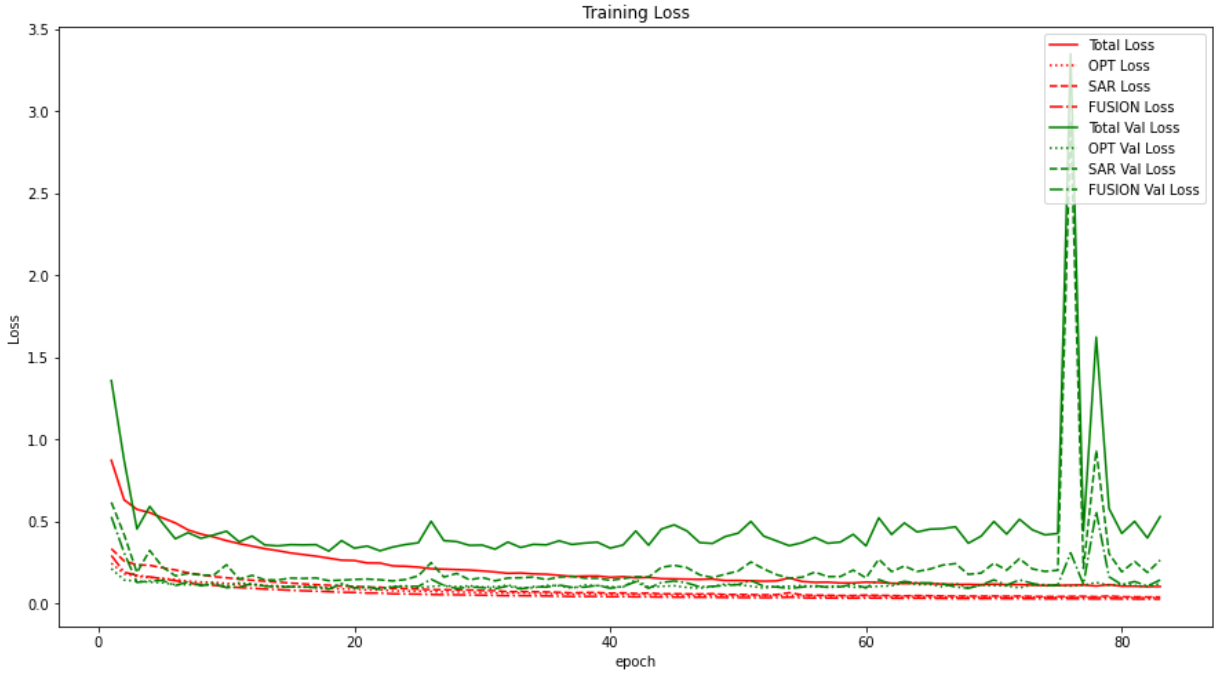
Show training history

In [7]:

```
plt.figure(figsize=(15, 8))
x = np.arange(len(history.history['loss']))+1
plt.plot(x, history.history['loss'], 'r-',label='Total Loss')
plt.plot(x, history.history['opt_loss'], 'r:',label='OPT Loss')
plt.plot(x, history.history['sar_loss'], 'r--',label='SAR Loss')
plt.plot(x, history.history['fusion_loss'], 'r-.',label='FUSION Loss')

plt.plot(x, history.history['val_loss'], 'g-',label='Total Val Loss')
plt.plot(x, history.history['val_opt_loss'], 'g:',label='OPT Val Loss')
plt.plot(x, history.history['val_sar_loss'], 'g--',label='SAR Val Loss')
plt.plot(x, history.history['val_fusion_loss'], 'g-.',label='FUSION Val Loss')
```

```
plt.title('Training Loss')
plt.ylabel('Loss')
plt.xlabel('epoch')
plt.legend(loc='upper right')
plt.savefig('graphics/Loss.png')
plt.show()
```

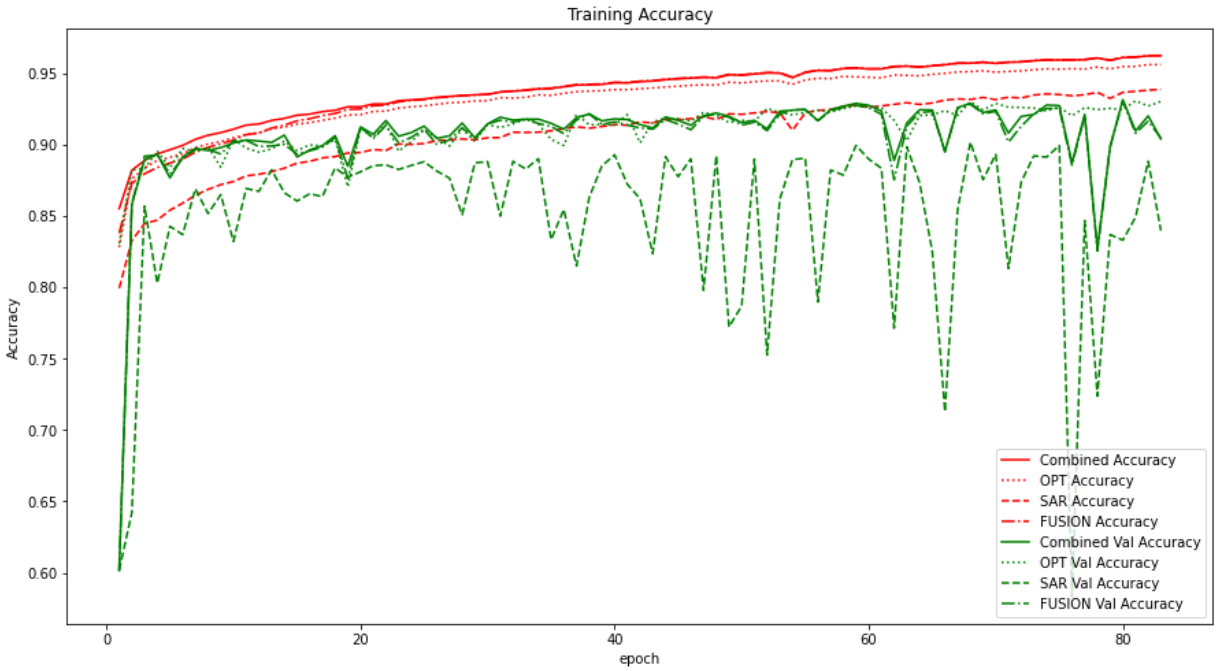


In [8]:

```
plt.figure(figsize=(15, 8))
x = np.arange(len(history.history['loss']))+1
plt.plot(x, history.history['combined_accuracy'], 'r-',label='Combined Accuracy')
plt.plot(x, history.history['opt_accuracy'], 'r:',label='OPT Accuracy')
plt.plot(x, history.history['sar_accuracy'], 'r--',label='SAR Accuracy')
plt.plot(x, history.history['fusion_accuracy'], 'r-.',label='FUSION Accuracy')

plt.plot(x, history.history['val_combined_accuracy'], 'g-',label='Combined Val Accur
plt.plot(x, history.history['val_opt_accuracy'], 'g:',label='OPT Val Accuracy')
plt.plot(x, history.history['val_sar_accuracy'], 'g--',label='SAR Val Accuracy')
plt.plot(x, history.history['val_fusion_accuracy'], 'g-.',label='FUSION Val Accuracy

plt.title('Training Accuracy')
plt.ylabel('Accuracy')
plt.xlabel('epoch')
plt.legend(loc='lower right')
plt.savefig('graphics/Accuracy.png')
plt.show()
```

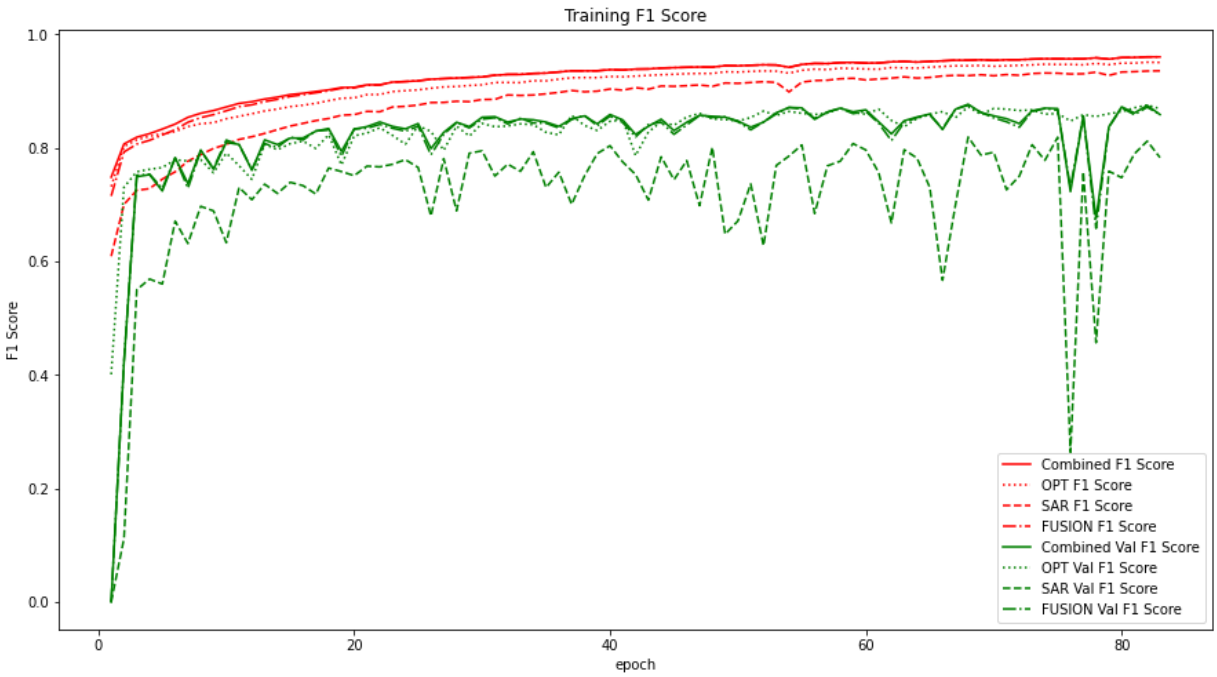


In [9]:

```
plt.figure(figsize=(15, 8))
x = np.arange(len(history.history['loss']))+1
plt.plot(x, history.history['combined_f1score'], 'r-',label='Combined F1 Score')
plt.plot(x, history.history['opt_f1score'], 'r:',label='OPT F1 Score')
plt.plot(x, history.history['sar_f1score'], 'r--',label='SAR F1 Score')
plt.plot(x, history.history['fusion_f1score'], 'r-.',label='FUSION F1 Score')

plt.plot(x, history.history['val_combined_f1score'], 'g-',label='Combined Val F1 Sco
plt.plot(x, history.history['val_opt_f1score'], 'g:',label='OPT Val F1 Score')
plt.plot(x, history.history['val_sar_f1score'], 'g--',label='SAR Val F1 Score')
plt.plot(x, history.history['val_fusion_f1score'], 'g-.',label='FUSION Val F1 Score'

plt.title('Training F1 Score')
plt.ylabel('F1 Score')
plt.xlabel('epoch')
plt.legend(loc='lower right')
plt.savefig('graphics/F1score.png')
plt.show()
```



Evaluation

In [10]:

```
opt_avg_prec_list = []
sar_avg_prec_list = []
fusion_avg_prec_list = []
combined_avg_prec_list = []


pred_path = params_patches['pred_path']
shutil.rmtree(pred_path, ignore_errors=True)
os.makedirs(pred_path)


for tile_n in params_patches['test_tiles']:
    dl_test.set_tile(int(tile_n))

    shape_tile = shapes_json[str(tile_n)]

    y_true = np.load(os.path.join(params_patches['tiles_path'], params_patches['labe
    y_true = to_categorical(y_true, 3)

    predictions_opt = []
    predictions_sar = []
    predictions_fusion = []
    predictions_combined = []

    for batch in tqdm(range(len(dl_test))):
        pred = model.predict_on_batch(dl_test[batch][0])
        predictions_opt.append(pred[0])
        predictions_sar.append(pred[1])
        predictions_fusion.append(pred[2])
        predictions_combined.append(pred[3])

    predictions_opt = np.concatenate(predictions_opt, axis=0)
    predictions_sar = np.concatenate(predictions_sar, axis=0)
    predictions_fusion = np.concatenate(predictions_fusion, axis=0)
    predictions_combined = np.concatenate(predictions_combined, axis=0)

    predictions_opt_rec = reconstruct_image(predictions_opt, params_patches['patch_s
    predictions_sar_rec = reconstruct_image(predictions_sar, params_patches['patch_s
    predictions_fusion_rec = reconstruct_image(predictions_fusion, params_patches['p
    predictions_combined_rec = reconstruct_image(predictions_combined, params_patche

    np.save(os.path.join(params_patches['pred_path'], f'pred_opt_{tile_n:02d}.npy'),
    np.save(os.path.join(params_patches['pred_path'], f'pred_sar_{tile_n:02d}.npy'),
    np.save(os.path.join(params_patches['pred_path'], f'pred_fusion_{tile_n:02d}.npy
    np.save(os.path.join(params_patches['pred_path'], f'pred_combined_{tile_n:02d}.n

    opt_avg_prec = average_precision_score(y_true[:, :, 1].flatten(), predictions_op
    sar_avg_prec = average_precision_score(y_true[:, :, 1].flatten(), predictions_sa
    fusion_avg_prec = average_precision_score(y_true[:, :, 1].flatten(), predictions
    combined_avg_prec = average_precision_score(y_true[:, :, 1].flatten(), predictio

    opt_avg_prec_list.append(opt_avg_prec)
    sar_avg_prec_list.append(sar_avg_prec)
    fusion_avg_prec_list.append(fusion_avg_prec)
    combined_avg_prec_list.append(combined_avg_prec)

    print(f'Precision Average (Class 1) of OPT prediction of tile {tile_n} is {opt_a
    print(f'Precision Average (Class 1) of SAR prediction of tile {tile_n} is {sar_a
    print(f'Precision Average (Class 1) of FUSION prediction of tile {tile_n} is {fu
    print(f'Precision Average (Class 1) of COMBINED prediction of tile {tile_n} is {

    opt_avg_prec = average_precision_score(y_true[:, :, 0].flatten(), predictions_op
```

```
    sar_avg_prec = average_precision_score(y_true[:, :, 0].flatten(), predictions_sa
    fusion_avg_prec = average_precision_score(y_true[:, :, 0].flatten(), predictions
    combined_avg_prec = average_precision_score(y_true[:, :, 0].flatten(), predictio

    print(f'Precision Average (Class 0) of OPT prediction of tile {tile_n} is {opt_a
    print(f'Precision Average (Class 0) of SAR prediction of tile {tile_n} is {sar_a
    print(f'Precision Average (Class 0) of FUSION prediction of tile {tile_n} is {fu
    print(f'Precision Average (Class 0) of COMBINED prediction of tile {tile_n} is {
```

```
100%|██████████| 558/558 [02:22<00:00,  3.92it/s]
Precision Average (Class 1) of OPT prediction of tile 2 is 0.7403
Precision Average (Class 1) of SAR prediction of tile 2 is 0.5680
Precision Average (Class 1) of FUSION prediction of tile 2 is 0.7684
Precision Average (Class 1) of COMBINED prediction of tile 2 is 0.7522
Precision Average (Class 0) of OPT prediction of tile 2 is 0.9678
Precision Average (Class 0) of SAR prediction of tile 2 is 0.9422
Precision Average (Class 0) of FUSION prediction of tile 2 is 0.9680
Precision Average (Class 0) of COMBINED prediction of tile 2 is 0.9652
100%|██████████| 558/558 [02:30<00:00,  3.72it/s]
Precision Average (Class 1) of OPT prediction of tile 4 is 0.3939
Precision Average (Class 1) of SAR prediction of tile 4 is 0.4602
Precision Average (Class 1) of FUSION prediction of tile 4 is 0.5231
Precision Average (Class 1) of COMBINED prediction of tile 4 is 0.5708
Precision Average (Class 0) of OPT prediction of tile 4 is 0.9684
Precision Average (Class 0) of SAR prediction of tile 4 is 0.9381
Precision Average (Class 0) of FUSION prediction of tile 4 is 0.9667
Precision Average (Class 0) of COMBINED prediction of tile 4 is 0.9656
100%|██████████| 558/558 [02:21<00:00,  3.93it/s]
Precision Average (Class 1) of OPT prediction of tile 5 is 0.8148
Precision Average (Class 1) of SAR prediction of tile 5 is 0.6272
Precision Average (Class 1) of FUSION prediction of tile 5 is 0.8204
Precision Average (Class 1) of COMBINED prediction of tile 5 is 0.8071
Precision Average (Class 0) of OPT prediction of tile 5 is 0.9778
Precision Average (Class 0) of SAR prediction of tile 5 is 0.9568
Precision Average (Class 0) of FUSION prediction of tile 5 is 0.9785
Precision Average (Class 0) of COMBINED prediction of tile 5 is 0.9764
100%|██████████| 558/558 [02:29<00:00,  3.73it/s]
Precision Average (Class 1) of OPT prediction of tile 9 is 0.7147
Precision Average (Class 1) of SAR prediction of tile 9 is 0.5803
Precision Average (Class 1) of FUSION prediction of tile 9 is 0.7590
Precision Average (Class 1) of COMBINED prediction of tile 9 is 0.7192
Precision Average (Class 0) of OPT prediction of tile 9 is 0.9884
Precision Average (Class 0) of SAR prediction of tile 9 is 0.8163
Precision Average (Class 0) of FUSION prediction of tile 9 is 0.9769
Precision Average (Class 0) of COMBINED prediction of tile 9 is 0.9804
100%|██████████| 558/558 [02:30<00:00,  3.72it/s]
Precision Average (Class 1) of OPT prediction of tile 10 is 0.8098
Precision Average (Class 1) of SAR prediction of tile 10 is 0.6227
Precision Average (Class 1) of FUSION prediction of tile 10 is 0.8400
Precision Average (Class 1) of COMBINED prediction of tile 10 is 0.8061
Precision Average (Class 0) of OPT prediction of tile 10 is 0.9829
Precision Average (Class 0) of SAR prediction of tile 10 is 0.9646
Precision Average (Class 0) of FUSION prediction of tile 10 is 0.9825
Precision Average (Class 0) of COMBINED prediction of tile 10 is 0.9824
100%|██████████| 558/558 [02:23<00:00,  3.89it/s]
Precision Average (Class 1) of OPT prediction of tile 11 is 0.4859
Precision Average (Class 1) of SAR prediction of tile 11 is 0.1939
Precision Average (Class 1) of FUSION prediction of tile 11 is 0.4718
Precision Average (Class 1) of COMBINED prediction of tile 11 is 0.4452
Precision Average (Class 0) of OPT prediction of tile 11 is 0.9621
Precision Average (Class 0) of SAR prediction of tile 11 is 0.9375
Precision Average (Class 0) of FUSION prediction of tile 11 is 0.9623
Precision Average (Class 0) of COMBINED prediction of tile 11 is 0.9618
```

```
100%|██████████| 558/558 [02:11<00:00,  4.24it/s]
Precision Average (Class 1) of OPT prediction of tile 13 is 0.5916
Precision Average (Class 1) of SAR prediction of tile 13 is 0.2668
Precision Average (Class 1) of FUSION prediction of tile 13 is 0.5576
Precision Average (Class 1) of COMBINED prediction of tile 13 is 0.5101
Precision Average (Class 0) of OPT prediction of tile 13 is 0.9704
Precision Average (Class 0) of SAR prediction of tile 13 is 0.9011
Precision Average (Class 0) of FUSION prediction of tile 13 is 0.9681
Precision Average (Class 0) of COMBINED prediction of tile 13 is 0.9693
100%|██████████| 558/558 [02:13<00:00,  4.19it/s]
Precision Average (Class 1) of OPT prediction of tile 15 is 0.2086
Precision Average (Class 1) of SAR prediction of tile 15 is 0.0306
Precision Average (Class 1) of FUSION prediction of tile 15 is 0.2098
Precision Average (Class 1) of COMBINED prediction of tile 15 is 0.1964
Precision Average (Class 0) of OPT prediction of tile 15 is 0.9875
Precision Average (Class 0) of SAR prediction of tile 15 is 0.6986
Precision Average (Class 0) of FUSION prediction of tile 15 is 0.9760
Precision Average (Class 0) of COMBINED prediction of tile 15 is 0.9803
100%|██████████| 558/558 [02:13<00:00,  4.16it/s]
Precision Average (Class 1) of OPT prediction of tile 18 is 0.9223
Precision Average (Class 1) of SAR prediction of tile 18 is 0.7938
Precision Average (Class 1) of FUSION prediction of tile 18 is 0.9327
Precision Average (Class 1) of COMBINED prediction of tile 18 is 0.9315
Precision Average (Class 0) of OPT prediction of tile 18 is 0.8947
Precision Average (Class 0) of SAR prediction of tile 18 is 0.3600
Precision Average (Class 0) of FUSION prediction of tile 18 is 0.8664
Precision Average (Class 0) of COMBINED prediction of tile 18 is 0.8691
```

In [ ]: