Car Damage Detection Project

```
import os
from torchvision import datasets, transforms
from torch.utils.data import DataLoader
import torch
import torch.nn as nn
import torch.optim as optim
import torch.nn.functional as F
import time
import torchvision.models as models
from matplotlib import pyplot as plt
```

```
device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
device
```

```
device(type='cuda')
```

Load Data

```
image_transforms = transforms.Compose([
    transforms.RandomHorizontalFlip(),
    transforms.RandomRotation(10),
    transforms.ColorJitter(brightness=0.2, contrast=0.2),
    transforms.Resize((224, 224)),
    transforms.ToTensor(),
    transforms.Normalize(mean=[0.485, 0.456, 0.406], std=[0.229, 0.224, 0.225])
])
```

```
dataset_path = "./dataset"

dataset = datasets.ImageFolder(root=dataset_path, transform=image_transforms)
len(dataset)
```

```
2300
```

```
2300*0.75
```

```
1725.0
```

```
class_names = dataset.classes
class_names
```

```
['F_Breakage', 'F_Crushed', 'F_Normal', 'R_Breakage', 'R_Crushed', 'R_Normal']
```

```
num_classes = len(dataset.classes)
num_classes
```

```
6
```

```
train_size = int(0.75*len(dataset))
val_size = len(dataset) - train_size

train_size, val_size
```

```
(1725, 575)
```

```
from torch.utils.data import random_split

train_dataset, val_dataset = random_split(dataset, [train_size, val_size])
```

```
train_loader = DataLoader(train_dataset, batch_size=32, shuffle=True)
val_loader = DataLoader(val_dataset, batch_size=32, shuffle=True)
```

```
for images, labels in train_loader:
    print(images.shape)
    print(labels.shape)
    break
```

```
torch.Size([32, 3, 224, 224])
torch.Size([32])
```

```
labels[1]
```

```
tensor(0)
```

```
images[1].shape
```

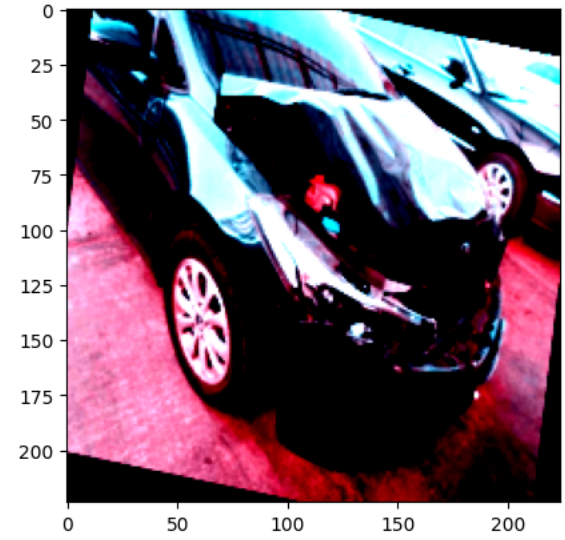
```
torch.Size([3, 224, 224])
```

```
images[1].permute(1,2,0).shape
```

```
torch.Size([224, 224, 3])
```

```
plt.imshow(images[1].permute(1,2,0))
plt.show()
```

```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers).
```



Model 1: CNN

```
class CarClassifierCNN(nn.Module):
    def __init__(self, num_classes):
        super().__init__()
        self.network = nn.Sequential(
            nn.Conv2d(in_channels=3, out_channels=16, kernel_size=3, stride=1, padding=1), # (16, 224, 224)
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2, stride=2, padding=0), # (16, 112, 112),
            nn.Conv2d(in_channels=16, out_channels=32, kernel_size=3, stride=1, padding=1),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2, stride=2, padding=0), # (32, 56, 56)
            nn.Conv2d(in_channels=32, out_channels=64, kernel_size=3, stride=1, padding=1),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2, stride=2, padding=0), # (64, 28, 28),
            nn.Flatten(),
            nn.Linear(64*28*28, 512),
            nn.ReLU(),
            nn.Linear(512, num_classes)
        )

    def forward(self, x):
        x = self.network(x)
        return x
```

```
images.size(0)
```

```
32
```

```
len(train_loader.dataset)
```

```
1725
```

```
def train_model(model, criterion, optimizer, epochs=5):
    start = time.time()

    for epoch in range(epochs):
        model.train()
```

```
        running_loss = 0.0
        for batch_num, (images, labels) in enumerate(train_loader):
            images, labels = images.to(device), labels.to(device)

            # Zero the parameter gradients
            optimizer.zero_grad()

            # Forward pass
            outputs = model(images)
            loss = criterion(outputs, labels)

            # Backward pass and optimization
            loss.backward()
            optimizer.step()

            if (batch_num+1) % 10 == 0:
                print(f"Batch: {batch_num+1}, Epoch: {epoch+1}, Loss: {loss.item():0.2f}")

            running_loss += loss.item() * images.size(0)

        epoch_loss = running_loss / len(train_loader.dataset)
        print(f"Epoch [{epoch+1}/{epochs}], Avg Loss: {epoch_loss:.4f}")

        # Validation
        model.eval()
        correct = 0
        total = 0
        all_labels = []
        all_predictions = []

        with torch.no_grad():
            for images, labels in val_loader:
                images, labels = images.to(device), labels.to(device)
                outputs = model(images)
                _, predicted = torch.max(outputs.data,1)
                total += labels.size(0)
                correct += (predicted == labels).sum().item()
                all_labels.extend(labels.cpu().numpy())
                all_predictions.extend(predicted.cpu().numpy())

            print(f"*** Validation Accuracy: {100 * correct / total:.2f}% ***")

    end = time.time()
    print(f"Execution time: {end - start} seconds")

    return all_labels, all_predictions


# Instantiate the model, loss function, and optimizer
model = CarClassifierCNN(num_classes=num_classes).to(device)
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(model.parameters(), lr=0.001)

all_labels, all_predictions = train_model(model, criterion, optimizer, epochs=10)
```

```
Batch: 10, Epoch: 1, Loss: 1.79
Batch: 20, Epoch: 1, Loss: 1.90
Batch: 30, Epoch: 1, Loss: 1.69
Batch: 40, Epoch: 1, Loss: 1.66
Batch: 50, Epoch: 1, Loss: 1.72
Epoch [1/10], Avg Loss: 1.7893
*** Validation Accuracy: 37.57% ***
Batch: 10, Epoch: 2, Loss: 1.48
Batch: 20, Epoch: 2, Loss: 1.63
Batch: 30, Epoch: 2, Loss: 1.43
Batch: 40, Epoch: 2, Loss: 1.63
Batch: 50, Epoch: 2, Loss: 1.34
Epoch [2/10], Avg Loss: 1.4138
*** Validation Accuracy: 45.22% ***
Batch: 10, Epoch: 3, Loss: 1.36
Batch: 20, Epoch: 3, Loss: 1.30
Batch: 30, Epoch: 3, Loss: 1.13
Batch: 40, Epoch: 3, Loss: 0.88
Batch: 50, Epoch: 3, Loss: 1.22
Epoch [3/10], Avg Loss: 1.2531
*** Validation Accuracy: 50.09% ***
Batch: 10, Epoch: 4, Loss: 1.18
Batch: 20, Epoch: 4, Loss: 1.04
Batch: 30, Epoch: 4, Loss: 1.11
Batch: 40, Epoch: 4, Loss: 1.03
Batch: 50, Epoch: 4, Loss: 0.88
Epoch [4/10], Avg Loss: 1.0982
*** Validation Accuracy: 51.30% ***
Batch: 10, Epoch: 5, Loss: 0.78
Batch: 20, Epoch: 5, Loss: 0.90
```

```
Batch: 30, Epoch: 5, Loss: 1.08
Batch: 40, Epoch: 5, Loss: 1.24
Batch: 50, Epoch: 5, Loss: 0.91
Epoch [5/10], Avg Loss: 0.9721
*** Validation Accuracy: 54.09% ***
Batch: 10, Epoch: 6, Loss: 1.06
Batch: 20, Epoch: 6, Loss: 0.90
Batch: 30, Epoch: 6, Loss: 0.78
Batch: 40, Epoch: 6, Loss: 0.99
Batch: 50, Epoch: 6, Loss: 0.75
Epoch [6/10], Avg Loss: 0.9053
*** Validation Accuracy: 56.87% ***
Batch: 10, Epoch: 7, Loss: 0.86
Batch: 20, Epoch: 7, Loss: 0.80
Batch: 30, Epoch: 7, Loss: 1.11
Batch: 40, Epoch: 7, Loss: 1.00
Batch: 50, Epoch: 7, Loss: 1.11
Epoch [7/10], Avg Loss: 0.8732
*** Validation Accuracy: 56.87% ***
Batch: 10, Epoch: 8, Loss: 0.71
Batch: 20, Epoch: 8, Loss: 0.85
Batch: 30, Epoch: 8, Loss: 0.83
Batch: 40, Epoch: 8, Loss: 1.01
Batch: 50, Epoch: 8, Loss: 1.09
Epoch [8/10], Avg Loss: 0.8449
*** Validation Accuracy: 55.30% ***
Batch: 10, Epoch: 9, Loss: 0.77
```

Model 2: CNN with Regularization

```
class CarClassifierCNNWithRegularization(nn.Module):
    def __init__(self, num_classes):
        super().__init__()
        self.network = nn.Sequential(
            nn.Conv2d(in_channels=3, out_channels=16, kernel_size=3, stride=1, padding=1), # (16, 224, 224)
            nn.BatchNorm2d(16),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2, stride=2, padding=0), # (16, 112, 112),
            nn.Conv2d(in_channels=16, out_channels=32, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(32),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2, stride=2, padding=0), # (32, 56, 56)
            nn.Conv2d(in_channels=32, out_channels=64, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(64),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2, stride=2, padding=0), # (64, 28, 28),
            nn.Flatten(),
            nn.Linear(64*28*28, 512),
            nn.ReLU(),
            nn.Dropout(0.5),
            nn.Linear(512, num_classes)
        )

    def forward(self, x):
        x = self.network(x)
        return x


model = CarClassifierCNNWithRegularization(num_classes=num_classes).to(device)
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(model.parameters(), lr=0.001, weight_decay=1e-4)

all_labels, all_predictions = train_model(model, criterion, optimizer,  epochs=10)
```

```
Epoch [2/10], Avg Loss: 1.4713
*** Validation Accuracy: 46.61% ***
Batch: 10, Epoch: 3, Loss: 1.21
Batch: 20, Epoch: 3, Loss: 1.22
Batch: 30, Epoch: 3, Loss: 1.37
Batch: 40, Epoch: 3, Loss: 1.32
Batch: 50, Epoch: 3, Loss: 1.28
Epoch [3/10], Avg Loss: 1.3041
*** Validation Accuracy: 50.09% ***
```

```
Epoch [5/10], Avg Loss: 1.2080
*** Validation Accuracy: 53.39% ***
Batch: 10, Epoch: 6, Loss: 1.12
Batch: 20, Epoch: 6, Loss: 1.10
Batch: 30, Epoch: 6, Loss: 1.12
Batch: 40, Epoch: 6, Loss: 1.09
Batch: 50, Epoch: 6, Loss: 0.90
Epoch [6/10], Avg Loss: 1.1537
*** Validation Accuracy: 51.83% ***
Batch: 10, Epoch: 7, Loss: 1.30
Batch: 20, Epoch: 7, Loss: 1.12
Batch: 30, Epoch: 7, Loss: 1.02
Batch: 40, Epoch: 7, Loss: 1.02
Batch: 50, Epoch: 7, Loss: 1.22
Epoch [7/10], Avg Loss: 1.1284
*** Validation Accuracy: 54.26% ***
Batch: 10, Epoch: 8, Loss: 0.95
Batch: 20, Epoch: 8, Loss: 1.21
Batch: 30, Epoch: 8, Loss: 1.12
Batch: 40, Epoch: 8, Loss: 1.16
Batch: 50, Epoch: 8, Loss: 0.92
Epoch [8/10], Avg Loss: 1.1307
*** Validation Accuracy: 52.52% ***
Batch: 10, Epoch: 9, Loss: 0.98
Batch: 20, Epoch: 9, Loss: 1.11
Batch: 30, Epoch: 9, Loss: 1.07
Batch: 40, Epoch: 9, Loss: 0.95
Batch: 50, Epoch: 9, Loss: 0.90
Epoch [9/10], Avg Loss: 1.0807
*** Validation Accuracy: 53.04% ***
Batch: 10, Epoch: 10, Loss: 1.00
Batch: 20, Epoch: 10, Loss: 1.09
Batch: 30, Epoch: 10, Loss: 1.36
Batch: 40, Epoch: 10, Loss: 0.96
Batch: 50, Epoch: 10, Loss: 1.07
Epoch [10/10], Avg Loss: 1.0907
*** Validation Accuracy: 50.43% ***
```

Model 3: Transfer Learning with EfficientNet

```
model = models.efficientnet_b0(weights='DEFAULT')
model.classifier[1].in_features
```

```
1280
```

```
class CarClassifierEfficientNet(nn.Module):
    def __init__(self, num_classes):
        super().__init__()
        self.model = models.efficientnet_b0(weights='DEFAULT')

        for param in self.model.parameters():
            param.requires_grad = False

        in_features = self.model.classifier[1].in_features

        self.model.classifier = nn.Sequential(
            nn.Dropout(0.5),
            nn.Linear(in_features, num_classes)
        )

    def forward(self, x):
        x = self.model(x)
        return x


model = CarClassifierEfficientNet(num_classes=num_classes).to(device)
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(filter(lambda p: p.requires_grad, model.parameters()), lr=0.001)

all_labels, all_predictions = train_model(model, criterion, optimizer, epochs=10)
```

```
Batch: 10, Epoch: 1, Loss: 1.69
Batch: 20, Epoch: 1, Loss: 1.55
Batch: 30, Epoch: 1, Loss: 1.47
Batch: 40, Epoch: 1, Loss: 1.30
Batch: 50, Epoch: 1, Loss: 1.23
Epoch [1/10], Avg Loss: 1.5018
*** Validation Accuracy: 52.70% ***
Batch: 10, Epoch: 2, Loss: 1.26
Batch: 20, Epoch: 2, Loss: 0.99
Batch: 30, Epoch: 2, Loss: 1.11
Batch: 40, Epoch: 2, Loss: 1.06
Batch: 50, Epoch: 2, Loss: 1.05
Epoch [2/10], Avg Loss: 1.1384
*** Validation Accuracy: 60.52% ***
```

```
Batch: 10, Epoch: 3, Loss: 0.86
Batch: 20, Epoch: 3, Loss: 1.01
Batch: 30, Epoch: 3, Loss: 0.94
Batch: 40, Epoch: 3, Loss: 1.00
Batch: 50, Epoch: 3, Loss: 1.13
Epoch [3/10], Avg Loss: 1.0067
*** Validation Accuracy: 62.78% ***
Batch: 10, Epoch: 4, Loss: 1.12
Batch: 20, Epoch: 4, Loss: 0.88
Batch: 30, Epoch: 4, Loss: 0.99
Batch: 40, Epoch: 4, Loss: 1.14
Batch: 50, Epoch: 4, Loss: 1.12
Epoch [4/10], Avg Loss: 0.9476
*** Validation Accuracy: 63.65% ***
Batch: 10, Epoch: 5, Loss: 0.90
Batch: 20, Epoch: 5, Loss: 0.92
Batch: 30, Epoch: 5, Loss: 0.82
Batch: 40, Epoch: 5, Loss: 0.92
Batch: 50, Epoch: 5, Loss: 0.99
Epoch [5/10], Avg Loss: 0.8969
*** Validation Accuracy: 66.78% ***
Batch: 10, Epoch: 6, Loss: 0.75
Batch: 20, Epoch: 6, Loss: 0.84
Batch: 30, Epoch: 6, Loss: 0.62
Batch: 40, Epoch: 6, Loss: 0.89
Batch: 50, Epoch: 6, Loss: 0.60
Epoch [6/10], Avg Loss: 0.8590
*** Validation Accuracy: 64.17% ***
Batch: 10, Epoch: 7, Loss: 0.90
Batch: 20, Epoch: 7, Loss: 0.81
Batch: 30, Epoch: 7, Loss: 0.80
Batch: 40, Epoch: 7, Loss: 0.87
Batch: 50, Epoch: 7, Loss: 0.96
Epoch [7/10], Avg Loss: 0.8399
*** Validation Accuracy: 65.39% ***
Batch: 10, Epoch: 8, Loss: 0.84
Batch: 20, Epoch: 8, Loss: 0.76
Batch: 30, Epoch: 8, Loss: 0.75
Batch: 40, Epoch: 8, Loss: 0.76
Batch: 50, Epoch: 8, Loss: 0.86
Epoch [8/10], Avg Loss: 0.8108
*** Validation Accuracy: 64.35% ***
Batch: 10, Epoch: 9, Loss: 1.08
Batch: 20, Epoch: 9, Loss: 0.84
```

Model 4: Transfer Learning with ResNet

```
# Load the pre-trained ResNet model
class CarClassifierResNet(nn.Module):
    def __init__(self, num_classes, dropout_rate=0.5):
        super().__init__()
        self.model = models.resnet50(weights='DEFAULT')
        # Freeze all layers except the final fully connected layer
        for param in self.model.parameters():
            param.requires_grad = False

        # Unfreeze layer4 and fc layers
        for param in self.model.layer4.parameters():
            param.requires_grad = True

        # Replace the final fully connected layer
        self.model.fc = nn.Sequential(
            nn.Dropout(dropout_rate),
            nn.Linear(self.model.fc.in_features, num_classes)
        )

    def forward(self, x):
        x = self.model(x)
        return x


model = CarClassifierResNet(num_classes=num_classes).to(device)
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(filter(lambda p: p.requires_grad, model.parameters()), lr=0.001)

labels, predictions = train_model(model, criterion, optimizer, epochs=10)
```

```
Batch: 10, Epoch: 1, Loss: 1.18
Batch: 20, Epoch: 1, Loss: 0.54
Batch: 30, Epoch: 1, Loss: 0.65
Batch: 40, Epoch: 1, Loss: 0.81
Batch: 50, Epoch: 1, Loss: 0.77
Epoch [1/10], Avg Loss: 0.8738
*** Validation Accuracy: 71.65% ***
Batch: 10, Epoch: 2, Loss: 0.35
Batch: 20, Epoch: 2, Loss: 0.43
```

```
Batch: 30, Epoch: 2, Loss: 0.47
Batch: 40, Epoch: 2, Loss: 0.50
Batch: 50, Epoch: 2, Loss: 0.43
Epoch [2/10], Avg Loss: 0.4777
*** Validation Accuracy: 78.78% ***
Batch: 10, Epoch: 3, Loss: 0.29
Batch: 20, Epoch: 3, Loss: 0.24
Batch: 30, Epoch: 3, Loss: 0.39
Batch: 40, Epoch: 3, Loss: 0.27
Batch: 50, Epoch: 3, Loss: 0.24
Epoch [3/10], Avg Loss: 0.3236
*** Validation Accuracy: 77.57% ***
Batch: 10, Epoch: 4, Loss: 0.20
Batch: 20, Epoch: 4, Loss: 0.16
Batch: 30, Epoch: 4, Loss: 0.30
Batch: 40, Epoch: 4, Loss: 0.17
Batch: 50, Epoch: 4, Loss: 0.60
Epoch [4/10], Avg Loss: 0.2373
*** Validation Accuracy: 80.52% ***
Batch: 10, Epoch: 5, Loss: 0.19
Batch: 20, Epoch: 5, Loss: 0.11
Batch: 30, Epoch: 5, Loss: 0.10
Batch: 40, Epoch: 5, Loss: 0.17
Batch: 50, Epoch: 5, Loss: 0.35
Epoch [5/10], Avg Loss: 0.2083
*** Validation Accuracy: 78.43% ***
Batch: 10, Epoch: 6, Loss: 0.16
Batch: 20, Epoch: 6, Loss: 0.05
Batch: 30, Epoch: 6, Loss: 0.05
Batch: 40, Epoch: 6, Loss: 0.09
Batch: 50, Epoch: 6, Loss: 0.21
Epoch [6/10], Avg Loss: 0.1362
*** Validation Accuracy: 77.22% ***
Batch: 10, Epoch: 7, Loss: 0.08
Batch: 20, Epoch: 7, Loss: 0.10
Batch: 30, Epoch: 7, Loss: 0.05
Batch: 40, Epoch: 7, Loss: 0.28
Batch: 50, Epoch: 7, Loss: 0.33
Epoch [7/10], Avg Loss: 0.1348
*** Validation Accuracy: 77.04% ***
Batch: 10, Epoch: 8, Loss: 0.21
Batch: 20, Epoch: 8, Loss: 0.03
Batch: 30, Epoch: 8, Loss: 0.03
Batch: 40, Epoch: 8, Loss: 0.41
Batch: 50, Epoch: 8, Loss: 0.12
Epoch [8/10], Avg Loss: 0.1087
*** Validation Accuracy: 80.52% ***
Batch: 10, Epoch: 9, Loss: 0.09
Batch: 20, Epoch: 9, Loss: 0.15
```

I ran hyperparameter tunning in another notebook and figured that the best parameters for resnet models are (1) Dropout rate = 0.2 (2) Learning Rate = 0.005

So now let's train the model once again with these best parameters

```
model = CarClassifierResNet(num_classes=num_classes, dropout_rate=0.2).to(device)
criterion = nn.CrossEntropyLoss()
optimizer = optim.Adam(filter(lambda p: p.requires_grad, model.parameters()), lr=0.005)

labels, predictions = train_model(model, criterion, optimizer, epochs=10)
```

```
Batch: 10, Epoch: 1, Loss: 1.56
Batch: 20, Epoch: 1, Loss: 0.99
Batch: 30, Epoch: 1, Loss: 0.88
Batch: 40, Epoch: 1, Loss: 0.48
Batch: 50, Epoch: 1, Loss: 0.76
Epoch [1/10], Avg Loss: 1.0021
*** Validation Accuracy: 71.65% ***
Batch: 10, Epoch: 2, Loss: 0.43
Batch: 20, Epoch: 2, Loss: 0.47
Batch: 30, Epoch: 2, Loss: 0.58
Batch: 40, Epoch: 2, Loss: 0.60
Batch: 50, Epoch: 2, Loss: 0.48
Epoch [2/10], Avg Loss: 0.5265
*** Validation Accuracy: 73.04% ***
Batch: 10, Epoch: 3, Loss: 0.38
Batch: 20, Epoch: 3, Loss: 0.23
Batch: 30, Epoch: 3, Loss: 0.23
Batch: 40, Epoch: 3, Loss: 0.26
Batch: 50, Epoch: 3, Loss: 0.30
Epoch [3/10], Avg Loss: 0.3634
*** Validation Accuracy: 80.87% ***
Batch: 10, Epoch: 4, Loss: 0.36
Batch: 20, Epoch: 4, Loss: 0.17
Batch: 30, Epoch: 4, Loss: 0.31
Batch: 40, Epoch: 4, Loss: 0.34
Batch: 50, Epoch: 4, Loss: 0.24
```

```
Epoch [4/10], Avg Loss: 0.2801
*** Validation Accuracy: 78.43% ***
Batch: 10, Epoch: 5, Loss: 0.23
Batch: 20, Epoch: 5, Loss: 0.07
Batch: 30, Epoch: 5, Loss: 0.12
Batch: 40, Epoch: 5, Loss: 0.27
Batch: 50, Epoch: 5, Loss: 0.31
Epoch [5/10], Avg Loss: 0.2194
*** Validation Accuracy: 81.22% ***
Batch: 10, Epoch: 6, Loss: 0.11
Batch: 20, Epoch: 6, Loss: 0.08
Batch: 30, Epoch: 6, Loss: 0.31
Batch: 40, Epoch: 6, Loss: 0.22
Batch: 50, Epoch: 6, Loss: 0.48
Epoch [6/10], Avg Loss: 0.1623
*** Validation Accuracy: 78.43% ***
Batch: 10, Epoch: 7, Loss: 0.07
Batch: 20, Epoch: 7, Loss: 0.02
Batch: 30, Epoch: 7, Loss: 0.10
Batch: 40, Epoch: 7, Loss: 0.02
Batch: 50, Epoch: 7, Loss: 0.29
Epoch [7/10], Avg Loss: 0.1330
*** Validation Accuracy: 77.04% ***
Batch: 10, Epoch: 8, Loss: 0.17
Batch: 20, Epoch: 8, Loss: 0.02
Batch: 30, Epoch: 8, Loss: 0.06
Batch: 40, Epoch: 8, Loss: 0.57
Batch: 50, Epoch: 8, Loss: 0.07
Epoch [8/10], Avg Loss: 0.1747
*** Validation Accuracy: 74.43% ***
Batch: 10, Epoch: 9, Loss: 0.17
Batch: 20, Epoch: 9, Loss: 0.05
```

Model Evaluation using Confusion Matrix and Classification Report

```
from sklearn.metrics import classification_report

report = classification_report(labels, predictions)
print(report)
```

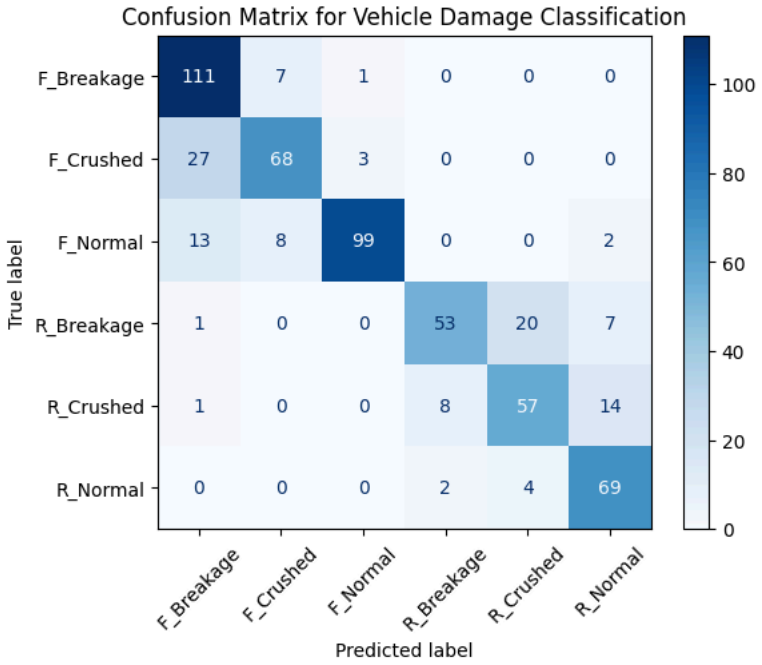
```
              precision    recall  f1-score   support

           0       0.73      0.93      0.82       119
           1       0.82      0.69      0.75        98
           2       0.96      0.81      0.88       122
           3       0.84      0.65      0.74        81
           4       0.70      0.71      0.71        80
           5       0.75      0.92      0.83        75

    accuracy                           0.79       575
   macro avg       0.80      0.79      0.79       575
weighted avg       0.81      0.79      0.79       575
```

```
import numpy as np
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
from matplotlib import pyplot as plt

conf_matrix = confusion_matrix(labels, predictions, labels=np.arange(num_classes))
disp = ConfusionMatrixDisplay(confusion_matrix=conf_matrix, display_labels=class_names)
disp.plot(cmap=plt.cm.Blues, xticks_rotation=45)
plt.title("Confusion Matrix for Vehicle Damage Classification")
plt.show()
```



Save the Model

```
torch.save(model.state_dict(), 'saved_model.pth')
```