```
import os
import json
from PIL import Image
import torch
import torchvision.transforms as T
import torchvision
import torch.nn as nn
import torch.optim as optim
from torch.utils.data import Dataset, DataLoader
import numpy as np
import matplotlib.pyplot as plt


from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remoun
```

```
# Paths to folders
image_folder = "/content/drive/MyDrive/DL Project/Pics/images"
mask_folder = "/content/drive/MyDrive/DL Project/Pics/annotation_mask"
device = torch.device("cuda")


# Unique RGB colors for each label, including background as black
label_colors = {
    "background": (0, 0, 0),          # Black for background
    "grilled chicken": (255, 0, 0),   # Red
    "paneer": (0, 255, 0),            # Green
    "eggplant": (0, 0, 255)           # Blue
}


# Convert RGB colors to class indices
color_to_class = {v: i for i, (k, v) in enumerate(label_colors.items())}


# Custom Dataset Class
class FoodSegmentationDataset(Dataset):
    def __init__(self, image_dir, mask_dir, transform=None, mask_transform=None):
        self.image_dir = image_dir
        self.mask_dir = mask_dir
        self.transform = transform
        self.mask_transform = mask_transform
        self.images = [f for f in os.listdir(image_dir) if f.endswith('.png')]

    def __len__(self):
        return len(self.images)

    def __getitem__(self, idx):
        img_name = self.images[idx]
        img_path = os.path.join(self.image_dir, img_name)
        mask_path = os.path.join(self.mask_dir, img_name)

        # Load image and mask
        image = Image.open(img_path).convert("RGB")
        mask = Image.open(mask_path).convert("RGB")

        # Apply transformations
        if self.transform:
            image = self.transform(image)
        if self.mask_transform:
            mask = self.mask_transform(mask)

        # Convert mask to class indices after transformations
        mask = self.rgb_to_class_indices(mask)

        return image, torch.tensor(mask, dtype=torch.long)

    def rgb_to_class_indices(self, mask):
        mask_np = np.array(mask)
        class_mask = np.zeros((mask_np.shape[0], mask_np.shape[1]), dtype=np.int64)
        for color, class_idx in color_to_class.items():
            class_mask[(mask_np == color).all(axis=2)] = class_idx
        return class_mask


# Data transformations
transform = T.Compose([
    T.Resize((512, 512)),
    T.RandomHorizontalFlip(p=0.5),
    T.RandomRotation(15),
```

```
        T.ColorJitter(brightness=0.3, contrast=0.3, saturation=0.3, hue=0.1),
        T.ToTensor(),
        T.Normalize(mean=[0.485, 0.456, 0.406], std=[0.229, 0.224, 0.225]),
    ])


    # Transformation for masks
    mask_transform = T.Resize((512, 512))


    #Dataset and DataLoader
    dataset = FoodSegmentationDataset(image_folder, mask_folder, transform=transform, mask_transform=mask_transform)
    train_size = int(0.8 * len(dataset))
    val_size = len(dataset) - train_size
    train_dataset, val_dataset = torch.utils.data.random_split(dataset, [train_size, val_size])
    train_loader = DataLoader(train_dataset, batch_size=8, shuffle=True)
    val_loader = DataLoader(val_dataset, batch_size=8, shuffle=False)


    # Model Class
    class EfficientNetSegmentation(nn.Module):
        def __init__(self, num_classes):
            super(EfficientNetSegmentation, self).__init__()
            self.backbone = torchvision.models.efficientnet_b0(pretrained=True).features
            self.upsample = nn.Sequential(
                nn.Conv2d(1280, num_classes, kernel_size=1),
                nn.Upsample(size=(512, 512), mode='bilinear', align_corners=False)
            )

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

        def forward(self, x):
            x = self.backbone(x)
            x = self.upsample(x)
            return x

    model = EfficientNetSegmentation(num_classes=len(label_colors))
```

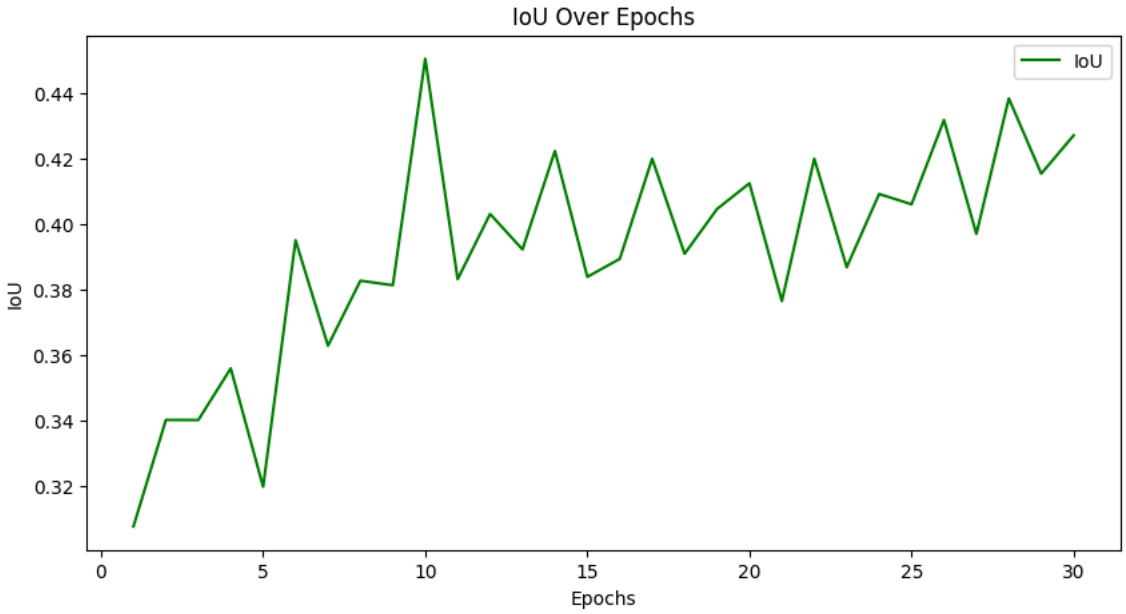
```
/usr/local/lib/python3.10/dist-packages/torchvision/models/_utils.py:208: UserWarning: The parameter 'pretrained' is dep
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/torchvision/models/_utils.py:223: UserWarning: Arguments other than a weight enu
  warnings.warn(msg)
```

```
    # Loss and optimizer
    class_weights = torch.tensor([0.1, 1.0, 1.0, 1.0]).to(device)
    criterion = nn.CrossEntropyLoss(weight=class_weights)
    optimizer = optim.AdamW(model.parameters(), lr=0.001)
    scheduler = optim.lr_scheduler.StepLR(optimizer, step_size=5, gamma=0.5)


    def calculate_iou(pred, target, num_classes):
        pred = pred.argmax(dim=1)
        pred = pred.to(device)
        target = target.to(device)

        iou_list = []
        for cls in range(num_classes):
            pred_mask = (pred == cls)
            target_mask = (target == cls)
            intersection = (pred_mask & target_mask).sum().float()
            union = (pred_mask | target_mask).sum().float()
            if union == 0:
                iou = torch.tensor(1.0, device=device) if intersection == 0 else torch.tensor(0.0, device=device)
            else:
                iou = intersection / union
            iou_list.append(iou)
        return torch.mean(torch.stack(iou_list))



    # Training function with IoU calculation, model saving, and graph plotting
    def train_model(model, train_loader, val_loader, criterion, optimizer, scheduler, num_epochs=20):
        model = model.to(device)
        train_losses = []
        val_losses = []
        iou_scores = []
        best_iou = 0.0
        best_model = None

        for epoch in range(num_epochs):
            model.train()
            train_loss = 0
            for images, masks in train_loader:
```

```
                images, masks = images.to(device), masks.to(device)

                optimizer.zero_grad()
                outputs = model(images)
                loss = criterion(outputs, masks)
                loss.backward()
                optimizer.step()

                train_loss += loss.item()

            scheduler.step()

            # Validation
            model.eval()
            val_loss = 0
            iou = 0
            with torch.no_grad():
                for images, masks in val_loader:
                    images, masks = images.to(device), masks.to(device)
                    outputs = model(images)
                    loss = criterion(outputs, masks)
                    val_loss += loss.item()

                    iou += calculate_iou(outputs, masks, num_classes=len(label_colors))

            train_loss /= len(train_loader)
            val_loss /= len(val_loader)
            iou /= len(val_loader)

            train_losses.append(train_loss)
            val_losses.append(val_loss)
            iou_scores.append(iou.item())

            print(f"Epoch {epoch+1}/{num_epochs}, Training Loss: {train_loss:.4f}, Validation Loss: {val_loss:.4f}, IoU: {iou:.4

            # Save the best model based on IoU
            if iou > best_iou:
                best_iou = iou
                best_model = model.state_dict()
                torch.save(best_model, "/content/best_model.pth")

        # Plot training and validation loss
        plt.figure(figsize=(10, 5))
        plt.plot(range(1, num_epochs + 1), train_losses, label='Training Loss')
        plt.plot(range(1, num_epochs + 1), val_losses, label='Validation Loss')
        plt.xlabel('Epochs')
        plt.ylabel('Loss')
        plt.title('Training and Validation Loss')
        plt.legend()
        plt.show()

        # Plot IoU graph
        plt.figure(figsize=(10, 5))
        plt.plot(range(1, num_epochs + 1), iou_scores, label='IoU', color='green')
        plt.xlabel('Epochs')
        plt.ylabel('IoU')
        plt.title('IoU Over Epochs')
        plt.legend()
        plt.show()

        print(f"Best IoU: {best_iou:.4f} achieved with the saved model.")
        return best_iou



    def visualize_predictions(model, dataloader):
        model.eval()
        with torch.no_grad():
            for images, masks in dataloader:
                images = images.to(device)
                outputs = model(images)
                preds = outputs.argmax(1).cpu().numpy()

                for i in range(len(images)):
                    pred_rgb = np.zeros((preds[i].shape[0], preds[i].shape[1], 3), dtype=np.uint8)
                    mask_rgb = np.zeros((masks[i].shape[0], masks[i].shape[1], 3), dtype=np.uint8)

                    for color, class_idx in color_to_class.items():
                        pred_rgb[preds[i] == class_idx] = color
                        mask_rgb[masks[i].cpu().numpy() == class_idx] = color


                    title_text = "Prediction"
```

```
                # Plot the images
                fig, axs = plt.subplots(1, 3, figsize=(15, 5))
                axs[0].imshow(images[i].cpu().permute(1, 2, 0))
                axs[0].set_title("Input Image")
                axs[1].imshow(mask_rgb)
                axs[1].set_title("Ground Truth Mask")
                axs[2].imshow(pred_rgb)
                axs[2].set_title(title_text)
                plt.show()
                break


# Train the model and visualize
best_iou = train_model(model, train_loader, val_loader, criterion, optimizer, scheduler, num_epochs = 30)
```

```
Epoch 1/30, Training Loss: 1.1172, Validation Loss: 0.8474, IoU: 0.3076
Epoch 2/30, Training Loss: 0.8465, Validation Loss: 0.6065, IoU: 0.3401
Epoch 3/30, Training Loss: 0.7108, Validation Loss: 0.6694, IoU: 0.3401
Epoch 4/30, Training Loss: 0.6605, Validation Loss: 0.5098, IoU: 0.3558
Epoch 5/30, Training Loss: 0.7324, Validation Loss: 0.8833, IoU: 0.3197
Epoch 6/30, Training Loss: 0.6715, Validation Loss: 0.5341, IoU: 0.3949
Epoch 7/30, Training Loss: 0.5274, Validation Loss: 0.4938, IoU: 0.3628
Epoch 8/30, Training Loss: 0.5224, Validation Loss: 0.4982, IoU: 0.3826
Epoch 9/30, Training Loss: 0.4907, Validation Loss: 0.5015, IoU: 0.3812
Epoch 10/30, Training Loss: 0.4865, Validation Loss: 0.4425, IoU: 0.4504
Epoch 11/30, Training Loss: 0.4527, Validation Loss: 0.5656, IoU: 0.3831
Epoch 12/30, Training Loss: 0.4492, Validation Loss: 0.4621, IoU: 0.4030
Epoch 13/30, Training Loss: 0.4166, Validation Loss: 0.5103, IoU: 0.3922
Epoch 14/30, Training Loss: 0.4056, Validation Loss: 0.4331, IoU: 0.4222
Epoch 15/30, Training Loss: 0.4053, Validation Loss: 0.5090, IoU: 0.3838
Epoch 16/30, Training Loss: 0.3901, Validation Loss: 0.5203, IoU: 0.3893
Epoch 17/30, Training Loss: 0.3865, Validation Loss: 0.4573, IoU: 0.4198
Epoch 18/30, Training Loss: 0.3849, Validation Loss: 0.5720, IoU: 0.3908
Epoch 19/30, Training Loss: 0.3722, Validation Loss: 0.5456, IoU: 0.4045
Epoch 20/30, Training Loss: 0.3533, Validation Loss: 0.4990, IoU: 0.4123
Epoch 21/30, Training Loss: 0.4127, Validation Loss: 0.6128, IoU: 0.3764
Epoch 22/30, Training Loss: 0.3877, Validation Loss: 0.4891, IoU: 0.4198
Epoch 23/30, Training Loss: 0.3464, Validation Loss: 0.5378, IoU: 0.3867
Epoch 24/30, Training Loss: 0.3562, Validation Loss: 0.5392, IoU: 0.4091
Epoch 25/30, Training Loss: 0.3576, Validation Loss: 0.5542, IoU: 0.4059
Epoch 26/30, Training Loss: 0.3685, Validation Loss: 0.4631, IoU: 0.4317
Epoch 27/30, Training Loss: 0.3488, Validation Loss: 0.5266, IoU: 0.3969
Epoch 28/30, Training Loss: 0.3509, Validation Loss: 0.4370, IoU: 0.4383
Epoch 29/30, Training Loss: 0.3459, Validation Loss: 0.5085, IoU: 0.4153
Epoch 30/30, Training Loss: 0.3427, Validation Loss: 0.5013, IoU: 0.4270
```




```
Best IoU: 0.4504 achieved with the saved model.
```

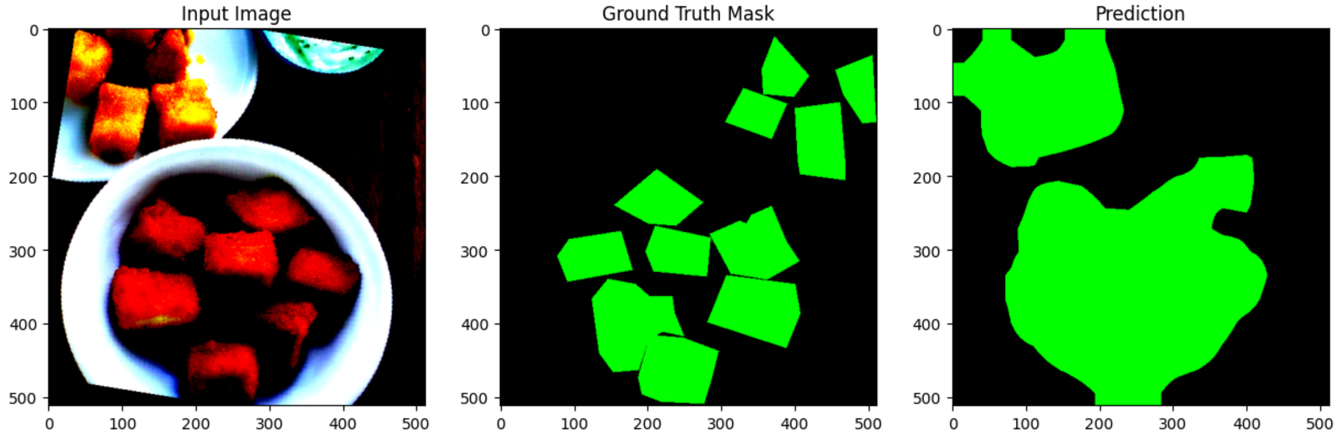
```
# Define paths and ensure the checkpoint exists
best_model_path = os.path.join("/content/", 'best_model.pth'
```

```
if os.path.exists(best_model_path):
    model.load_state_dict(torch.load(best_model_path))
    model.eval()
    print("Best model loaded successfully.")
else:
```

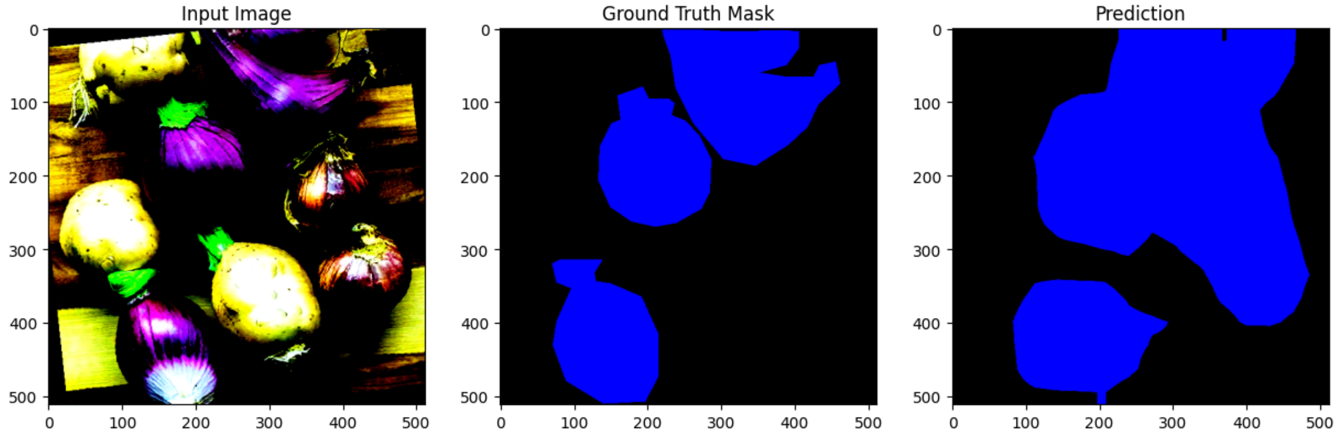
```
Best model loaded successfully.
<ipython-input-19-192478864cd0>:5: FutureWarning: You are using `torch.load` with `weights_only=False` (the current defa
  model.load_state_dict(torch.load(best_model_path))
```

```
visualize_predictions(model, val_loader)
```

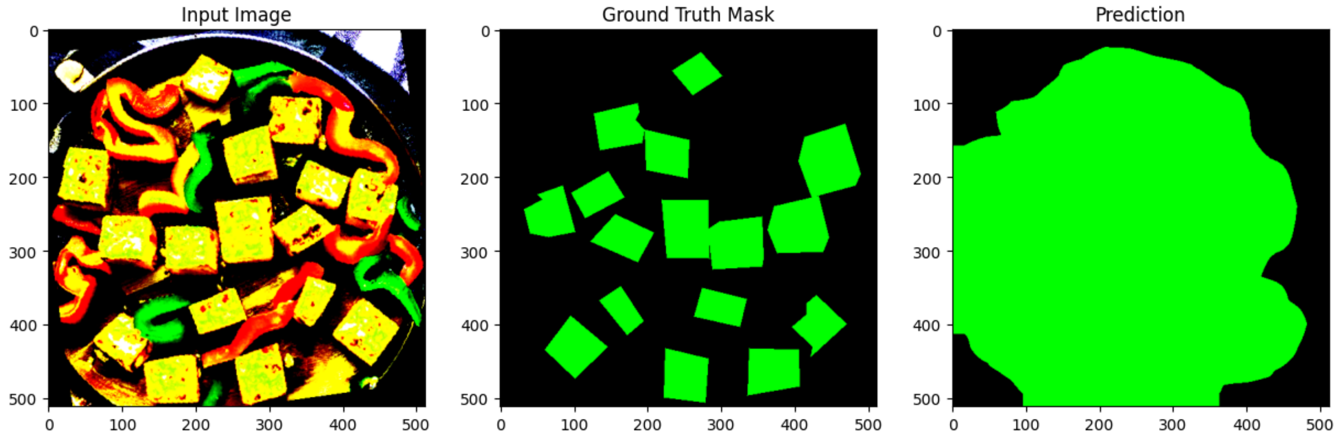
```
WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255]
```




```
WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255]
```




```
WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255]
```




```
WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255]
```