NUTRIEST

MTH 354 FINAL PROJECT
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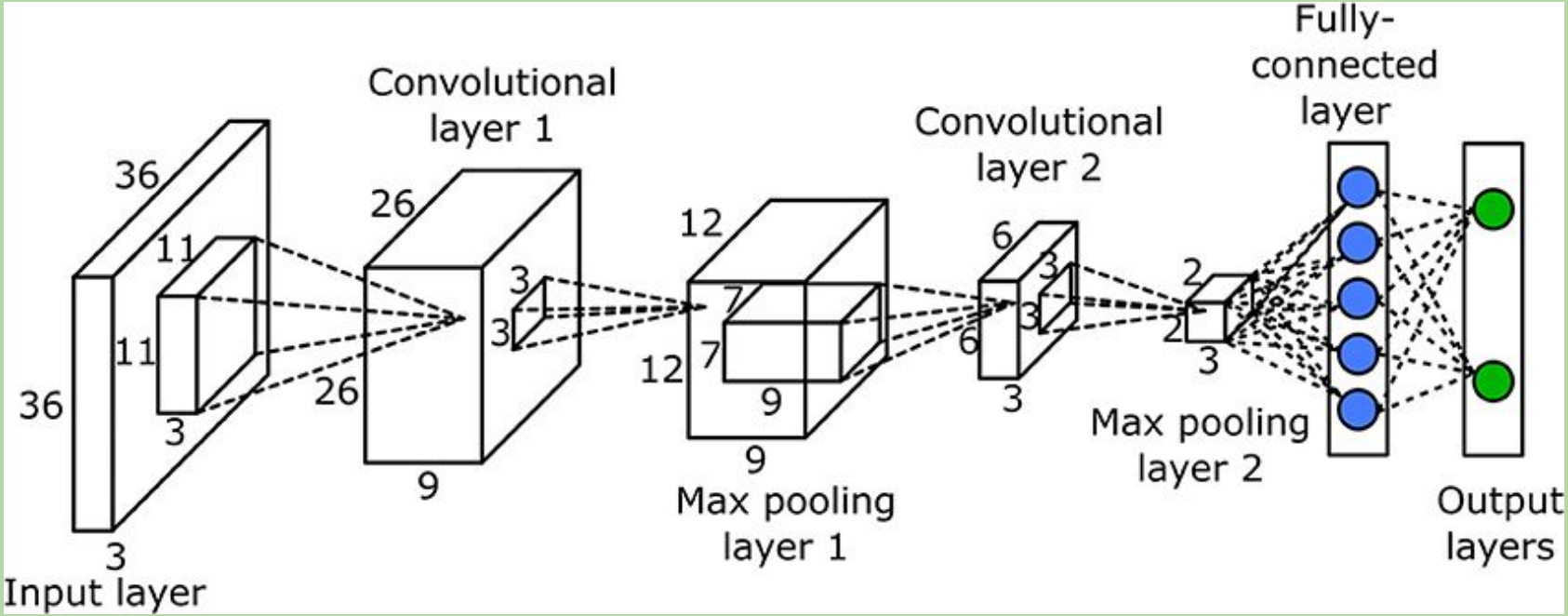
Nutriest is a convolutional neural network that estimates the nutritional content of food based on an image.

Convolution Operation

- Central and essential for feature extraction from images
- “Slides” a kernel across an input image to produce feature map

$$s(t) = \int x(a)w(t-a)da.$$


36
11
11
36
3
3
Input layer
Convolutional
layer 1
26
3
3
26
9
12
7
12
7
9
9
Max pooling
layer 1
Convolutional
layer 2
6
3
6
3
3
Max pooling
layer 2
2
2
3
Fully-
connected
layer
Output
layers

CNN diagram

The data used to train this model, called **Nutriest**, comes from the 'Recipe Images with Nutritional Information' dataset from Kaggle. It contains 2,167 images of various recipes, each paired with detailed nutritional information including calories, protein, carbohydrates (carbs), sugars, salts,saturates, and fats. I will only be focusing on my calorie count and macros, so: **kcal, proteins, carbs, and fats** for the output.

Considering the number of images used to train this model is relatively low, and a few images will likely be wrangled and removed from the training dataset, I will focus on optimizing generability for this model.

The goal with this project is to train a Convolutional Neural Network (CNN) to predict nutritional content from food images, to potentially serve as a quicker and efficient way to track meal content and support my healthy eating journey.

Nutriest demonstrates the potential of deep learning in health and dietary planning.

DATA

- Kaggle
- 2,167 Images
- KCal, Proteins, Carbs, Fats

```
Mounted at /content/drive
   index                                          image  carbs   fat  fibre  \
0      1   recipe-image-legacy-id-46013_11-99b8eda.jpg   30.0  11.0    2.0
1      2   recipe-image-legacy-id-743466_11-e87df17.jpg   38.0   7.0    2.0
2      3  recipe-image-legacy-id-1119465_11-4aebb21.jpg   22.0  17.0    1.0
3      4  recipe-image-legacy-id-1201816_10-7f0a38f.jpg   32.0   9.0    2.0
4      9  recipe-image-legacy-id-1025484_11-f56ab42.jpg   25.0  11.0    1.0

    kcal  protein  salt  saturates  sugars
0  275.0     17.0  1.99        6.0     4.0
1  240.0      8.0  1.37        2.0     1.0
2  294.0     13.0  1.50        9.0     1.0
3  250.0     12.0  1.00        5.0     3.0
4  218.0      6.0  0.60        6.0     1.0
```

FILTERING

```
# COMBINING NUTRITIONAL AND IMAGE DATA
# ---------------------

images, missing_images, valid_indices = load_images(data, images_path)


print(f"Loaded {len(images)} images.")
print(f"MISSING {len(missing_images)} IMAGES: {missing_images}")

# removing missing images data from data.csv nutritional info
data_filtered = data.iloc[valid_indices]
print(f"Filtered data contains {len(data_filtered)} rows.")


x_im = np.array(images)
# y_labs = data[['kcal', 'protein', 'carbs', 'fat']].values  # output
y_labs = data_filtered[['kcal', 'protein', 'carbs', 'fat']].values

print(f"x_im shape: {x_im.shape}, y_labs shape: {y_labs.shape}")

x_im = x_im / 255.0  # normalize to range [0, 1] -- tutorials are doing this
```

```
IMG not found: /content/drive/My Drive/nutriest/images/roasted-summer-veg-casserole-3c459e9.png
IMG not found: /content/drive/My Drive/nutriest/images/Jerk-Style-Cauliflower-With-Coconut-Rice-2c54f98.jpg
IMG not found: /content/drive/My Drive/nutriest/images/Giant-Couscous-Salad-With-Charred-Veg-Tangy-Pesto-aea3737.jpg
IMG not found: /content/drive/My Drive/nutriest/images/Giant-Couscous-Salad-With-Charred-Veg-Tangy-Pesto-aea3737.jpg
IMG not found: /content/drive/My Drive/nutriest/images/KimchiPancakes-e591d25.jpg
IMG not found: /content/drive/My Drive/nutriest/images/TteokbokkiSpicyRiceCakes-b78e346.jpg
IMG not found: /content/drive/My Drive/nutriest/images/Vegan-carbonara-ebf05ee.jpg
IMG not found: /content/drive/My Drive/nutriest/images/Giant-Couscous-Salad-With-Charred-Veg-Tangy-Pesto-aea3737.jpg
IMG not found: /content/drive/My Drive/nutriest/images/Vegan-carbonara-ebf05ee.jpg
Loaded 1249 images.
MISSING 9 IMAGES: ['roasted-summer-veg-casserole-3c459e9.png', 'Jerk-Style-Cauliflower-With-Coconut-Rice-2c54f98.jpg',
Filtered data contains 1249 rows.
x_im shape: (1249, 224, 224, 3), y_labs shape: (1249, 4)
```

TESTING AND TRAINING SETS

Splitting the dataset into Testing and Training sets

```
[ ]  # SPLITTING DATASET
     # --------------------

     X_train, X_test, y_train, y_test = train_test_split(x_im, y_labs, test_size=0.2, random_state=42)

     print(f"training shape: {X_train.shape}, {y_train.shape}")
     print(f"testing shape: {X_test.shape}, {y_test.shape}")
```

```
training shape: (999, 224, 224, 3), (999, 4)
testing shape: (250, 224, 224, 3), (250, 4)
```

2 Models: MVP & COMPLEX MODEL

MVP BASIC MODEL

MVP: A Basic CNN

```
# BUILDING THE BASIC MODEL MVP
# ----------------------------

basic_model = Sequential([
    Conv2D(32, (3, 3), activation='relu', input_shape=(224, 224, 3)),
    MaxPooling2D((2, 2)),
    Conv2D(64, (3, 3), activation='relu'),
    MaxPooling2D((2, 2)),
    Flatten(),
    Dense(128, activation='relu'),
    Dropout(0.3),
    Dense(4, activation='linear')
])

basic_model.compile(optimizer='adam', loss='mean_squared_error', metrics=['mae'])
basic_model.summary()
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/convolutional/base_conv.py:107: UserWarning:
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
Model: "sequential"
```

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 222, 222, 32)	896
max_pooling2d (MaxPooling2D)	(None, 111, 111, 32)	0
conv2d_1 (Conv2D)	(None, 109, 109, 64)	18,496
max_pooling2d_1 (MaxPooling2D)	(None, 54, 54, 64)	0
flatten (Flatten)	(None, 186624)	0
dense (Dense)	(None, 128)	23,888,000
dropout (Dropout)	(None, 128)	0
dense_1 (Dense)	(None, 4)	516

```
Total params: 23,907,908 (91.20 MB)
Trainable params: 23,907,908 (91.20 MB)
Non-trainable params: 0 (0.00 B)
```

MVP BASIC MODEL

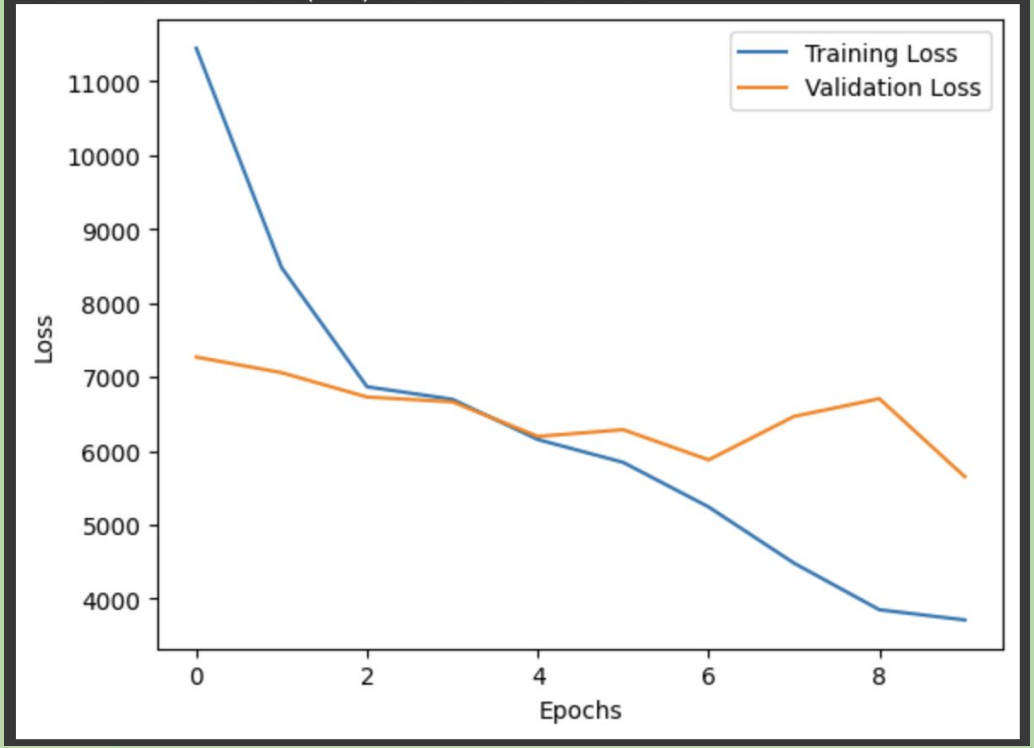
```
# TRAINING THE BASIC MODEL -- this step takes a few minutes.
# ----------------------------

history = basic_model.fit(
    X_train, y_train,
    validation_data=(X_test, y_test),
    epochs=10,
    batch_size=32,
    verbose=1
)
```

```
Epoch 1/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 97s 3s/step - loss: 17008.5645 - mae: 72.7677 - val_loss: 7267.9834 - val_mae: 42.6918
Epoch 2/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 148s 3s/step - loss: 9817.6758 - mae: 57.9370 - val_loss: 7056.3301 - val_mae: 41.2919
Epoch 3/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 140s 3s/step - loss: 7155.5718 - mae: 49.5428 - val_loss: 6727.2788 - val_mae: 38.7254
Epoch 4/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 137s 3s/step - loss: 6882.8955 - mae: 47.2766 - val_loss: 6662.5220 - val_mae: 38.1129
Epoch 5/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 141s 3s/step - loss: 6375.1743 - mae: 43.6097 - val_loss: 6194.6743 - val_mae: 37.2951
Epoch 6/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 142s 3s/step - loss: 5652.1475 - mae: 42.5526 - val_loss: 6285.6440 - val_mae: 38.1420
Epoch 7/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 142s 3s/step - loss: 5369.0664 - mae: 40.6519 - val_loss: 5877.8779 - val_mae: 35.2990
Epoch 8/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 148s 3s/step - loss: 4684.0474 - mae: 36.6741 - val_loss: 6464.9653 - val_mae: 37.8565
Epoch 9/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 138s 3s/step - loss: 3767.1062 - mae: 34.2876 - val_loss: 6704.6289 - val_mae: 37.5257
Epoch 10/10
32/32 ━━━━━━━━━━━━━━━━━━━━ 141s 3s/step - loss: 3820.6270 - mae: 32.7374 - val_loss: 5650.7549 - val_mae: 32.6255
```

MVP BASIC MODEL

```
8/8 ━━━━━━━━━━━━━━━━━━━━ 8s 978ms/step - loss: 6442.5654 - mae: 34.3826
Loss: 5650.7548828125
Mean Absolute Error (MAE): 32.62554931640625
```



MODEL EVALUATION

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$$

MVP BASIC MODEL

```
[ ]  # TEST ONE PREDICTION/IMAGE
     # ---------------------

     sample_image = X_test[0]
     sample_label = y_test[0]

     # PREDICT
     # ---------------------

     predicted_label = basic_model.predict(sample_image[np.newaxis, ...])

     print(f"True Label: {sample_label}")
     print(f"Predicted Label: {predicted_label}")
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 272ms/step
True Label: [197.   9.  15.  11.]
Predicted Label: [[187.72221     3.4164011  22.206823    7.996737 ]]
```

COMPLEX MODEL

```
# BUILDING LAYERED MODEL
# ----------------------

nutriest_model = models.Sequential([
    layers.AveragePooling2D(pool_size=(6, 6), strides=3, input_shape=(300, 300, 3)),

    # three convolutional blocks:
    layers.Conv2D(64, kernel_size=3, activation='relu'),
    layers.MaxPooling2D(pool_size=(2, 2)),
    # layers.Dropout(0.3), # check -- is this best to prevent overfitting

    layers.Conv2D(128, kernel_size=3, activation='relu'),
    layers.MaxPooling2D(pool_size=(2, 2)),
    # layers.Dropout(0.4),

    layers.Conv2D(256, kernel_size=3, activation='relu'),
    layers.MaxPooling2D(pool_size=(2, 2)),
    # layers.Dropout(0.5),

    layers.GlobalAveragePooling2D(),

    # flatten layers
    # layers.Flatten(),
    layers.Dense(128, activation='relu'),
    layers.Dropout(0.5),
    layers.Dense(4, activation='linear')
])



nutriest_model.compile(optimizer='adam',
              loss='mean_squared_error',
              metrics=['mae'])

nutriest_model.summary()
```

```
/usr/local/lib/python3.10/dist-packages/keras/src/layers/pooling/base_pooling.py:23: UserW
  super().__init__(name=name, **kwargs)
```

Model: "sequential"

Layer (type)	Output Shape	Param #
average_pooling2d (AveragePooling2D)	(None, 99, 99, 3)	0
conv2d (Conv2D)	(None, 97, 97, 64)	1,792
max_pooling2d (MaxPooling2D)	(None, 48, 48, 64)	0
conv2d_1 (Conv2D)	(None, 46, 46, 128)	73,856
max_pooling2d_1 (MaxPooling2D)	(None, 23, 23, 128)	0
conv2d_2 (Conv2D)	(None, 21, 21, 256)	295,168
max_pooling2d_2 (MaxPooling2D)	(None, 10, 10, 256)	0
global_average_pooling2d (GlobalAveragePooling2D)	(None, 256)	0
dense (Dense)	(None, 128)	32,896
dropout (Dropout)	(None, 128)	0
dense_1 (Dense)	(None, 4)	516

Total params: 404,228 (1.54 MB)
Trainable params: 404,228 (1.54 MB)
Non-trainable params: 0 (0.00 B)

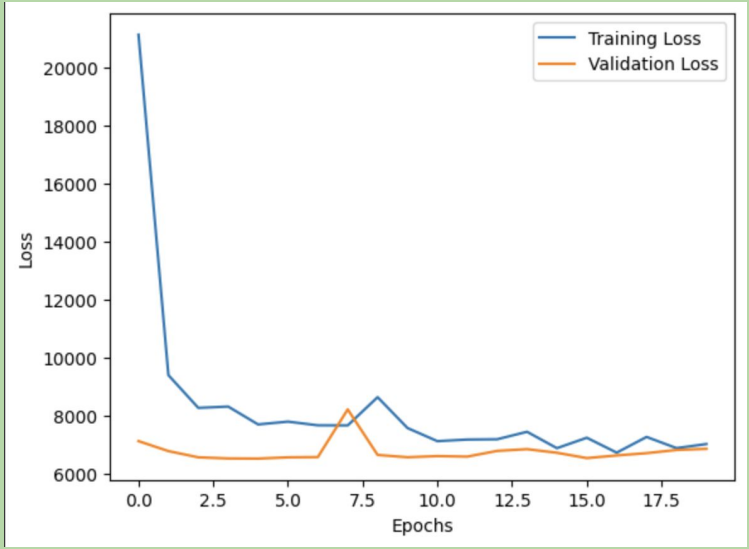
COMPLEX MODEL

```
# TRAINING LAYERED MODEL -- this takes a few minutes
# ----------------------

history = nutriest_model.fit(
    X_train, y_train,
    validation_data=(X_test, y_test),
    epochs=20,
    batch_size=32,
    verbose=1
)
```

```
Epoch 1/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 37s 1s/step - loss: 30784.7969 - mae: 96.2417 - val_loss: 7116.7773 - val_mae: 43.2624
Epoch 2/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 40s 1s/step - loss: 9550.3945 - mae: 61.8622 - val_loss: 6772.9053 - val_mae: 40.4235
Epoch 3/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 39s 1s/step - loss: 8108.6792 - mae: 55.5578 - val_loss: 6558.2637 - val_mae: 39.0567
Epoch 4/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 35s 1s/step - loss: 8530.0176 - mae: 54.6082 - val_loss: 6519.8584 - val_mae: 39.0887
Epoch 5/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 41s 1s/step - loss: 8148.3525 - mae: 52.1563 - val_loss: 6514.8257 - val_mae: 39.3694
Epoch 6/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 42s 1s/step - loss: 7832.4087 - mae: 50.0395 - val_loss: 6557.7114 - val_mae: 39.2310
Epoch 7/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 40s 1s/step - loss: 7905.6748 - mae: 49.3743 - val_loss: 6566.2739 - val_mae: 39.2318
Epoch 8/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 35s 1s/step - loss: 7503.4224 - mae: 47.5575 - val_loss: 8208.8857 - val_mae: 45.9414
Epoch 9/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 39s 1s/step - loss: 9371.0898 - mae: 51.8394 - val_loss: 6640.8545 - val_mae: 39.8688
Epoch 10/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 33s 1s/step - loss: 7962.6919 - mae: 47.4503 - val_loss: 6561.0381 - val_mae: 39.0620
Epoch 11/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 41s 1s/step - loss: 7423.8960 - mae: 45.5522 - val_loss: 6601.5098 - val_mae: 39.4521
Epoch 12/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 42s 1s/step - loss: 7164.0610 - mae: 44.5044 - val_loss: 6583.0552 - val_mae: 39.2958
Epoch 13/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 38s 1s/step - loss: 6896.6040 - mae: 43.4612 - val_loss: 6779.7686 - val_mae: 39.1329
Epoch 14/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 38s 1s/step - loss: 7389.9634 - mae: 44.5070 - val_loss: 6839.3442 - val_mae: 40.7366
Epoch 15/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 39s 1s/step - loss: 7323.6553 - mae: 44.7808 - val_loss: 6715.4282 - val_mae: 39.0227
Epoch 16/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 33s 1s/step - loss: 7883.5156 - mae: 44.7350 - val_loss: 6531.8184 - val_mae: 39.0001
Epoch 17/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 37s 1s/step - loss: 6718.8770 - mae: 42.1660 - val_loss: 6622.9683 - val_mae: 39.5696
Epoch 18/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 39s 1s/step - loss: 6831.6533 - mae: 41.9903 - val_loss: 6701.7158 - val_mae: 39.0049
Epoch 19/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 41s 1s/step - loss: 6852.7568 - mae: 41.5831 - val_loss: 6811.5254 - val_mae: 39.0568
Epoch 20/20
32/32 ━━━━━━━━━━━━━━━━━━━━ 40s 1s/step - loss: 6702.1235 - mae: 41.7521 - val_loss: 6850.9346 - val_mae: 40.5509
```

COMPLEX MODEL




```python
# EVALUATING THE LAYERED MODEL
# ----------------------

loss, mae = nutriest_model.evaluate(X_test, y_test, verbose=1)
print(f"Test Loss: {loss}")
print(f"Mean Absolute Error (MAE): {mae}")
```

```
8/8 ━━━━━━━━━━━━━━━━━━━━ 3s 393ms/step - loss: 7237.0073 - mae: 41.8321
Test Loss: 6719.2177734375
Mean Absolute Error (MAE): 39.99748611450195
```

MY TEST

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 83ms/step
True: [197.   9.  15.  11.]
Predicted: [[374.0013    19.404934  39.10752   14.619404]]
Loaded 2 images for testing.
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 123ms/step
Predicted Nutritional Values for 'mypizza.jpg':
Calories: 387.0
Protein: 20.1
Carbs: 40.5
Fat: 15.1
------------------------------
Predicted Nutritional Values for 'mypeaches.jpg':
Calories: 364.4
Protein: 18.9
Carbs: 38.1
Fat: 14.2
------------------------------
```