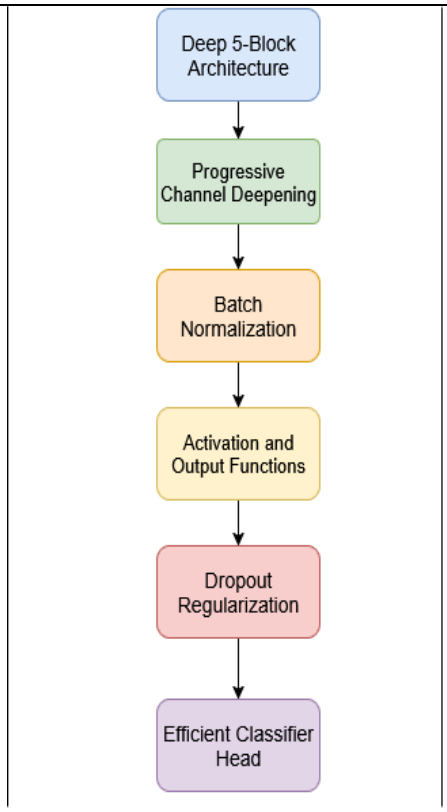
CUSTOM_CNN_FRUIT_CLASSIFICATION (Group-C)

Objective:

Design and implement a custom Convolutional Neural Network (CNN) from scratch for the task of classifying fruit images. The model is trained to distinguish between different types of fruits using a deep CNN architecture, optimized for generalization and accuracy.

Justification of Design Choices:

1. **5-Block CNN**
   Five convolutional blocks extract features at increasing complexity—from edges to high-level patterns.
2. **Channel Expansion**
   Filters increase from 32 to 256, enabling richer feature learning as spatial size decreases.
3. **Batch Normalization**
   Applied after each Conv2d to stabilize training and speed up convergence.
4. **Activations**
   ReLU adds non-linearity; Softmax in the output layer provides class probabilities.
5. **Dropout**
   Used with rates from 0.1 to 0.3 to reduce overfitting; extra 0.3 dropout in the dense head.
6. **Classifier Head**
   Flatten layer + dense layers convert extracted features into final class predictions.



Key Hyperparameters

- **Input Image Size**: (128, 128)
- **Batch Size**: 64
- **Optimizer**: Adam
- **Learning Rate**: Default (PyTorch default: 0.001)
- **Loss Function**: CrossEntropyLoss
- **Regularization**:
  - Dropout (0.1–0.3)
  - Batch Normalization after every Conv2d layer

Training Performance

- **Best Validation F1 Score**: 0.9868
- **Test Accuracy**: 0.9849
- **Training Loss**: Decreased from 0.8788 to 0.1034
- **Validation Loss**: Decreased from 0.3936 to 0.0416

Evaluation Metrics

Classification Report

Class	Precision	Recall	F1-Score	Support
Apple	1.00	0.95	0.97	310
Banana	0.99	1.00	0.99	303
Grape	1.00	1.00	1.00	313
Mango	0.99	0.98	0.99	312
Orange	0.95	1.00	0.97	286

Confusion Matrix Summary

- **Banana**: 302 correctly predicted, 1 misclassified as Apple
- **Mango**: 307 correctly predicted, 4 misclassified as Banana
- Other classes show similarly strong performance with minor misclassifications

Visualizations Summary

1. **Loss Curves**
    - Both training and validation losses consistently decrease
    - Indicates proper learning and no overfitting
2. **Validation F1 Score Curve**
    - F1 score steadily improves over epochs
    - Reaches 0.9868, showing strong generalization
3. **Confusion Matrix (Heatmap)**
    - Diagonal dominance
    - Minimal off-diagonal values indicate high classification accuracy

Conclusion

This custom-designed CNN demonstrates excellent performance on fruit quality classification. Achieving over 98% accuracy and F1-score, the model benefits from a deep and regularized architecture. The use of progressive feature extraction, normalization, and dropout ensures strong generalization.