FOOD IMAGE RECOGNITION
with Neural Network

DSI Capstone Project

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DIABETES

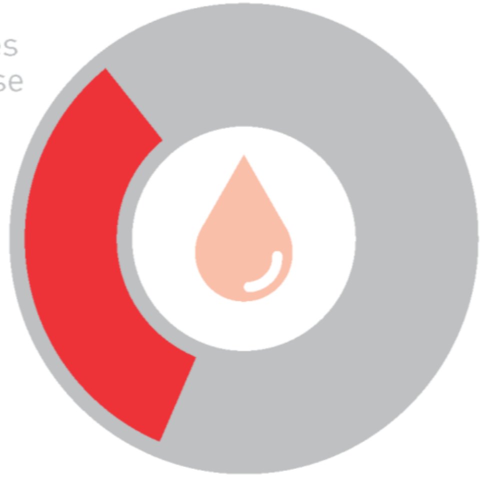
DIABETES IS ON THE RISE

422 MILLION adults have diabetes

82 MILLION in South East Asia

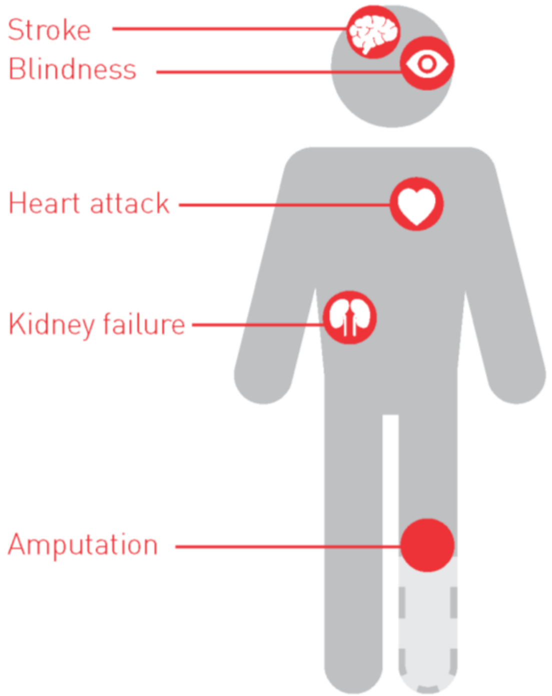
3.7 MILLION deaths due to diabetes and high blood glucose

1.5 MILLION deaths caused by diabetes



Consequences

Diabetes can lead to complications in many parts of the body and increase the risk of dying prematurely.



Risk factors for type 2 diabetes

Genetics, age and family history of diabetes can increase the likelihood of becoming diabetic and cannot be changed.
But some behaviours that increase risk can:

- Unhealthy diet
- 1 in 3 is overweight
- Physical inactivity
- 1 in 10 is obese

FOOD JOURNALLING

Time Consuming
Inefficient
Ineffective

Connectify.ai


You had...
Salad
Grilled Salmon
Water
at 12:24 PM
Add more
Public

Overall Roadmap

Target 1
Mobile App

User does food journaling by manually entering food they eat into the mobile application

Target 2
Food Classification

Instead of entering food manually, user takes a picture of the food and the model identifies the food

THIS PROJECT

Target 3
Nutrition Data Retrieval

User is then given the nutrition facts (Calorie, Carb, Fat, Protein) about the food identified in the image

THIS PROJECT

Target 4
Personalised Meal Recommendation

User is provided with personalized healthy meal recommendations

DATASET
Food Images

Food Images

Dataset	# Total Images	# Images per class	Source
Training Set	~26000	~900	Food 101 (Kaggle)
Validation Set	~2900	~100	Food 101 (Kaggle)
Testing Set	580	20	Web Scraping (Google/Bing)

29

Food Classes

Image Label Verification

samosa

Chicken curry

ramen

Caesar salad

Miso soup

Spring_rolls

hummus

pho

Pad thai

ramen

Peking_duck

Spring_rolls

Miso_soup

Peking_duck

Carrot_cake

Chicken curry

Carrot_cake

The dataset contains images irrelevant or ambiguous to the image labels.
These images were manually reviewed and removed accordingly.

Image Data Augmentation

Step
1
Random Flip

Images are randomly flipped horizontally

Step
2
Random Rotation

Images are randomly rotated clockwise/ anti-clockwise

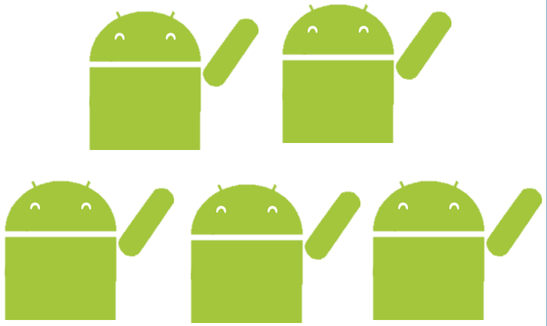
Step
3
Random Translation

Images are randomly shifted left/right

Why?

More Data

Model benefits from learning from a larger dataset



More Robust

Model becomes more robust to the real life images taken at different angles

Augmented Images Examples

After Image Data Augmentation…

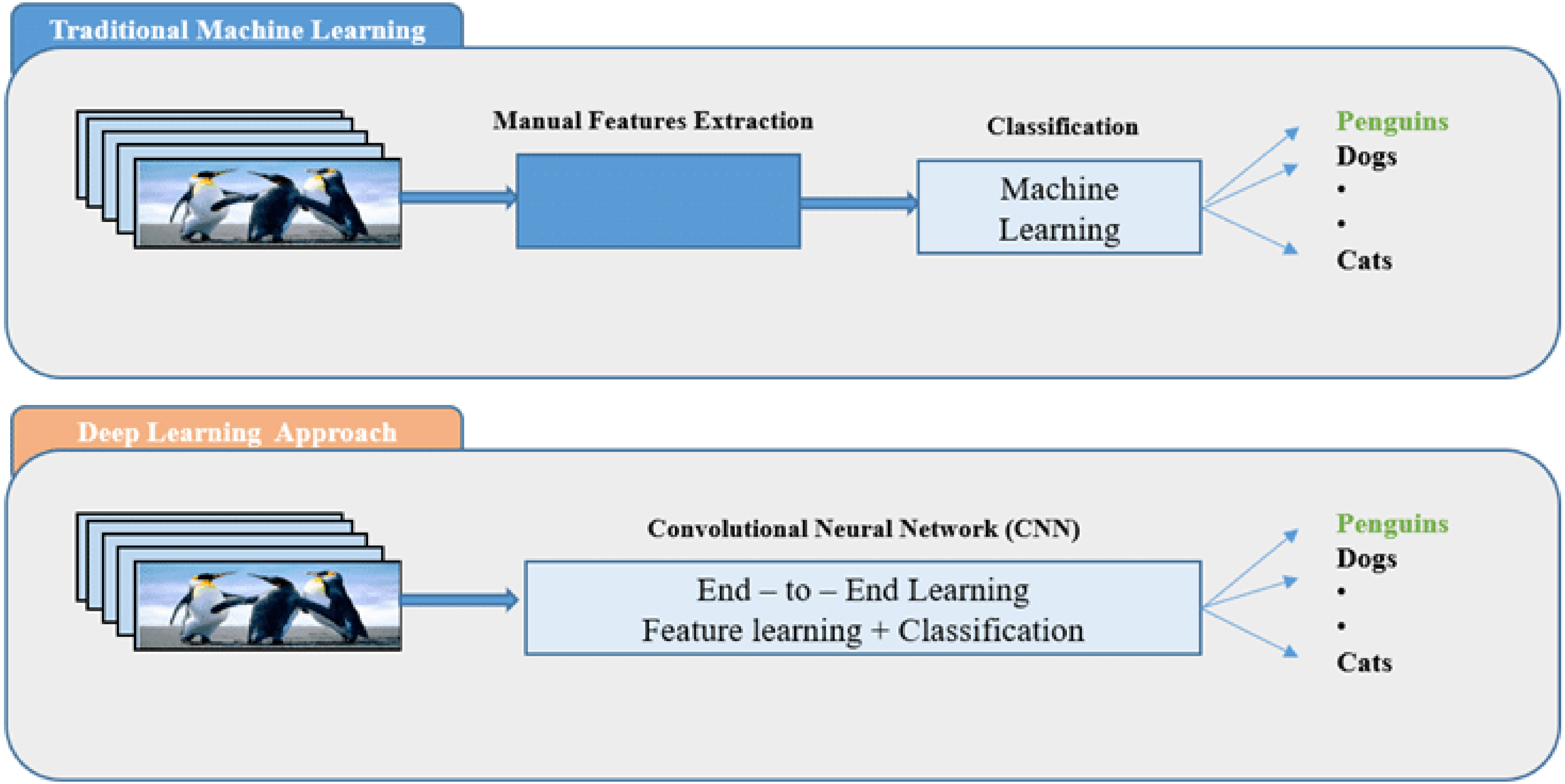
Dataset	# Total Images	# Images per class	Source
Training Set	~26000	~900	Food 101 (Kaggle)
Validation Set	~2900	~100	Food 101 (Kaggle)
Testing Set	580	20	Web Scraping (Google/Bing)

Removing irrelevant Images &
Performing Image Data Augmentation (two augmentations per image)

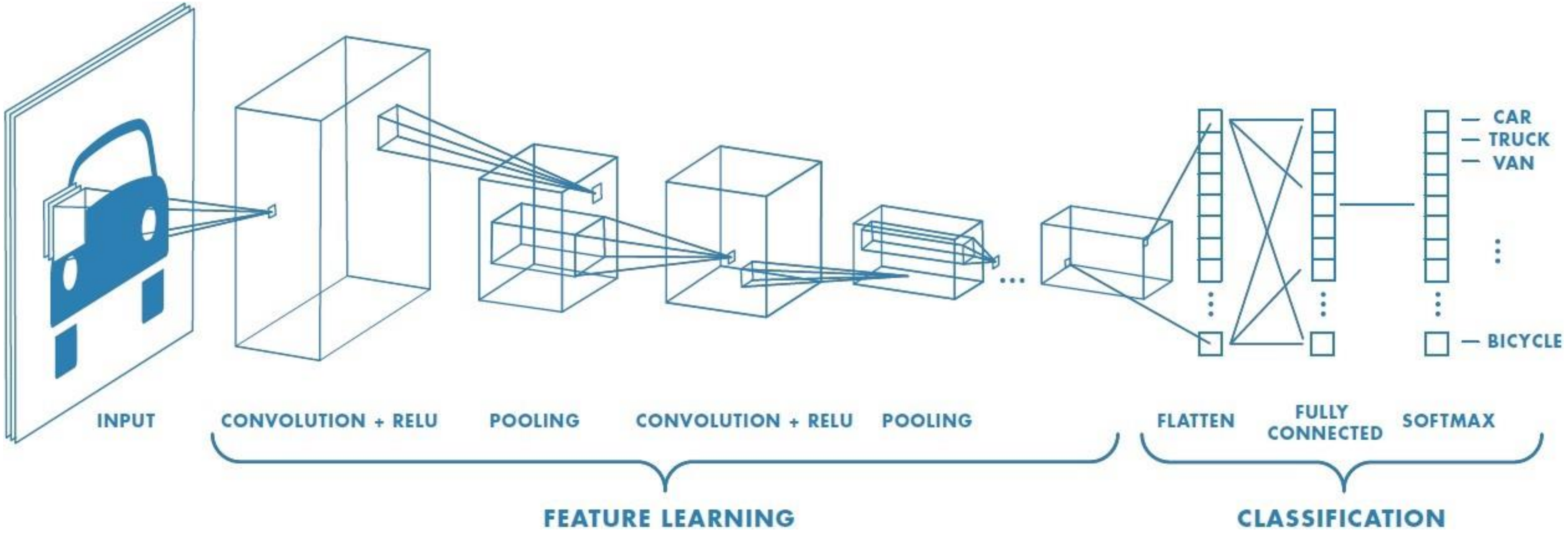
Dataset	# Total Images	# Images per class	Source
Training Set	~76000	~2600	Food 101 (Kaggle)
Validation Set	~8700	~300	Food 101 (Kaggle)
Testing Set	580	20	Web Scraping (Google/Bing)

Modelling

Why CNN?

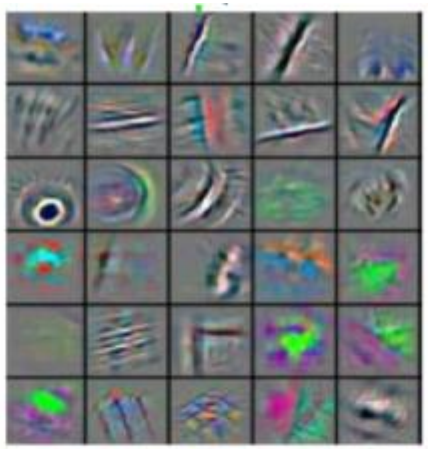

Traditional Machine Learning
Manual Features Extraction
Classification
Machine Learning
Penguins
Dogs
Cats
Deep Learning Approach
Convolutional Neural Network (CNN)
End – to – End Learning
Feature learning + Classification
Penguins
Dogs
Cats

CNN Flow

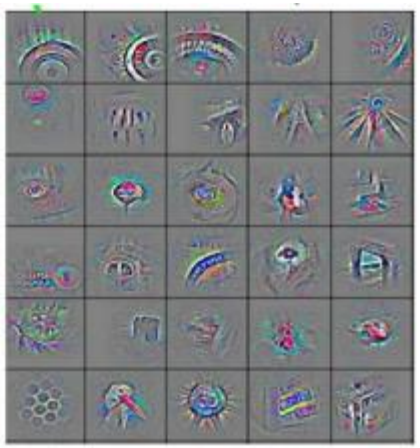


Level 1 Convolution

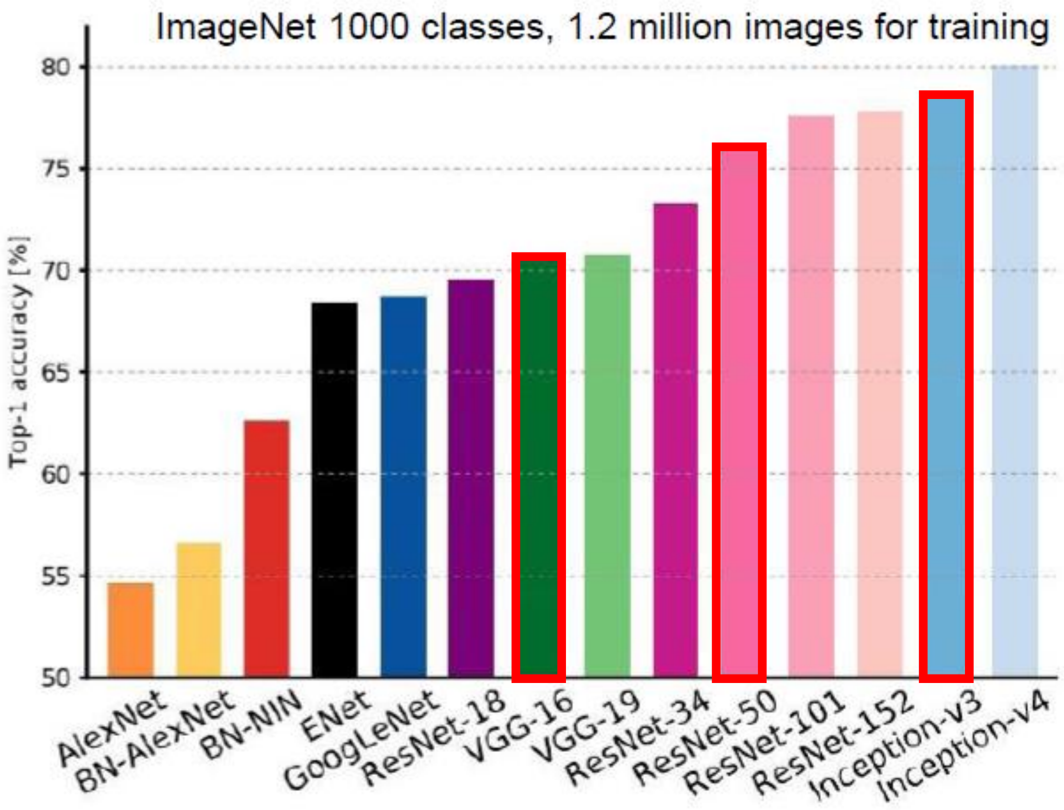
Level 2 Convolution

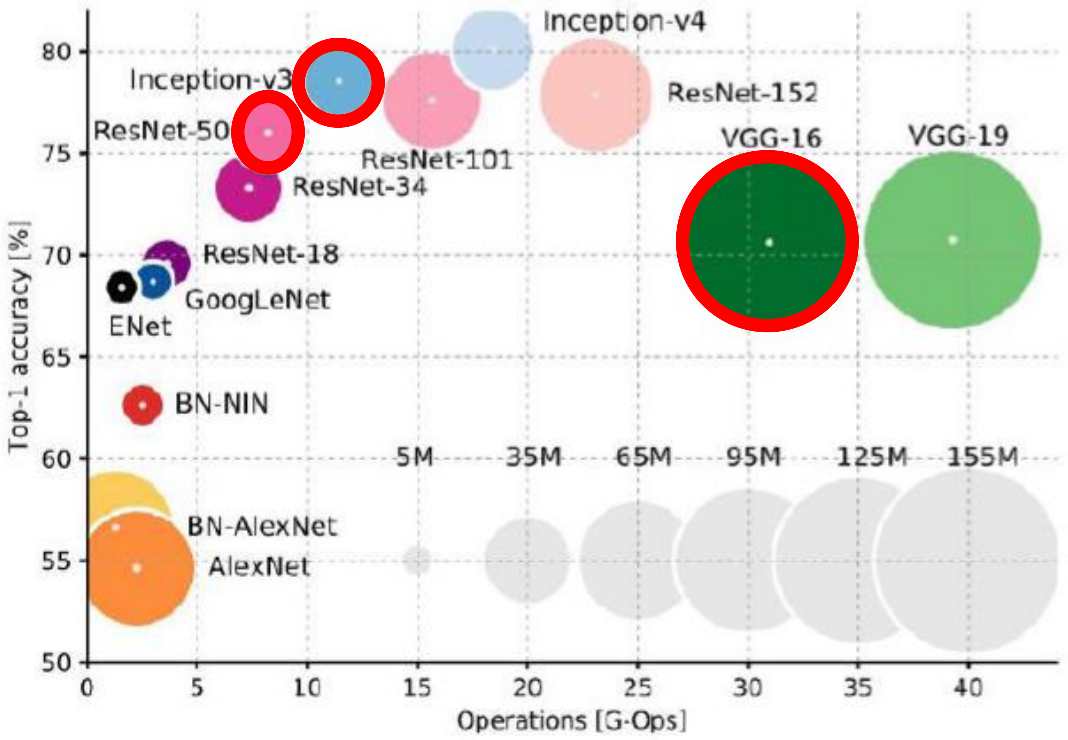


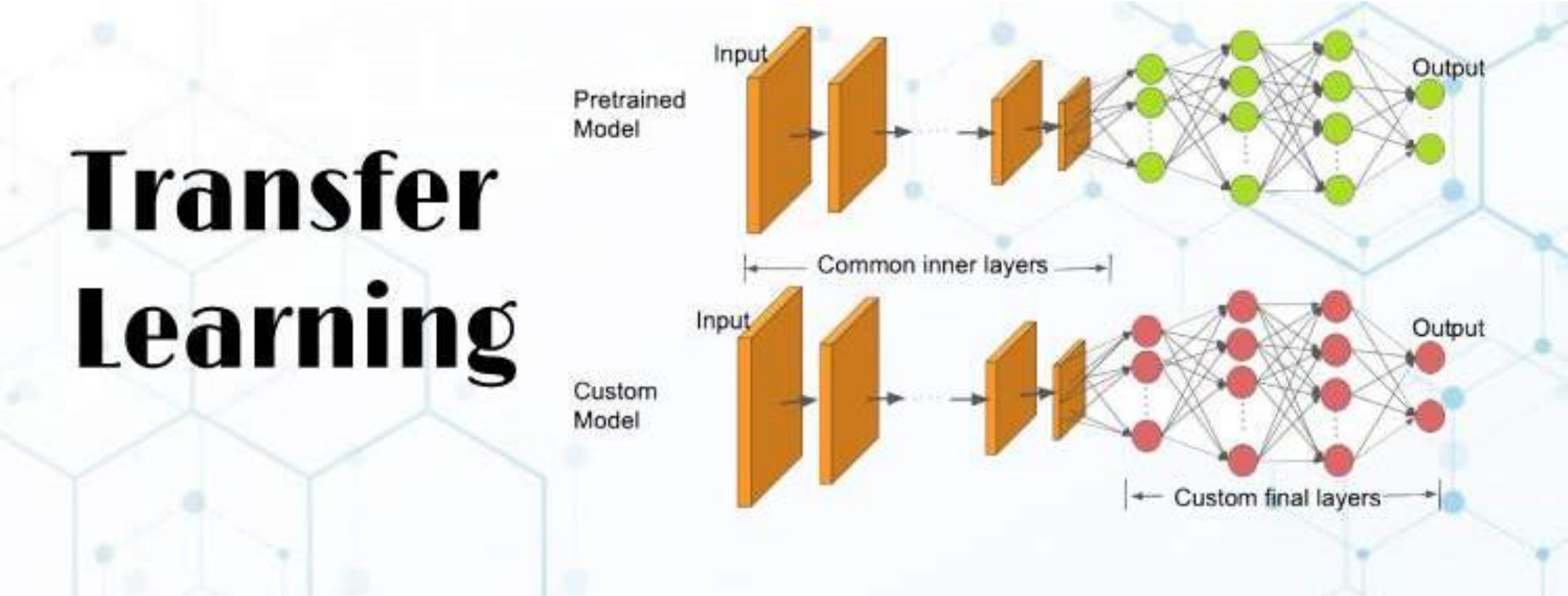
Level 3 Convolution



State of the Art
CNN Models






Transfer
Learning
Pretrained
Model
Input
Output
Common inner layers
Custom
Model
Input
Output
Custom final layers

Models Setups

CNN Models

- Custom Model (From Scratch)
- Inception V3 (Transfer Learning)
- ResNet 50 (Transfer Learning)
- Inception-ResNetV2 (Transfer Learning)
- VGG16 (Transfer Learning)

Configuration

- Optimizer: Adam
- Metric: Accuracy

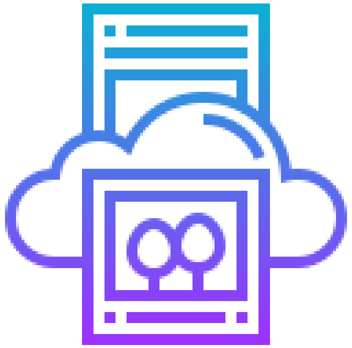
Model Specs

Model	# Layers	# Total Params	# Trainable Params
Custom	15	~5m	~5m
VGG16	16	~134m	~120k
VGG16 Dropout	15	~15m	~555k
InceptionV3 Dropout	49	~24m	~2m
InceptionV3 GAP	48	~22m	~60k
ResNet50	50	~24m	~60k
Inception-ResNetV2	164	~54m	~44k
Inception-ResNetV2 Dropout	165	~56m	~1.6m

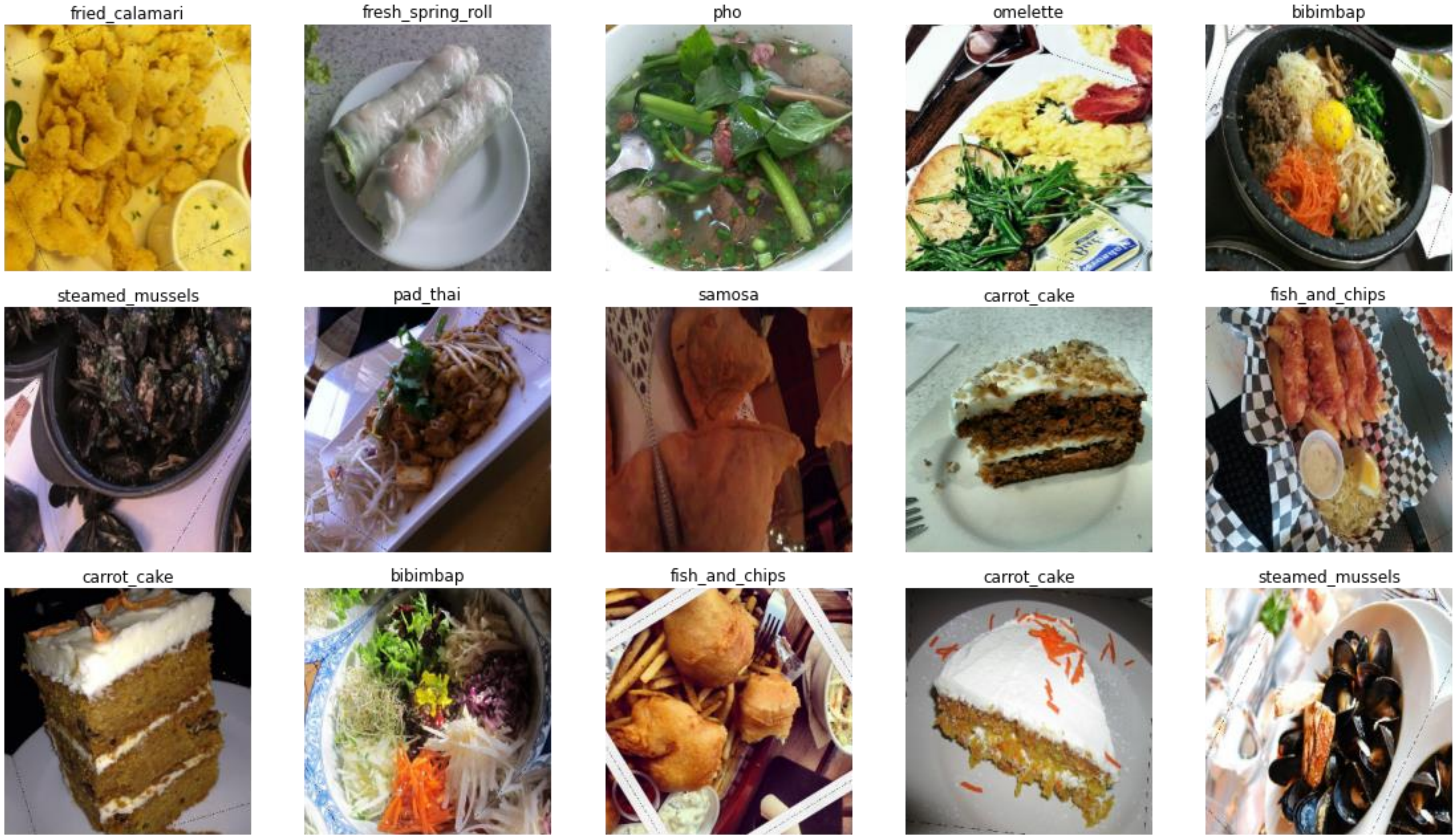
Image Preprocessing

Preprocessing Techniques

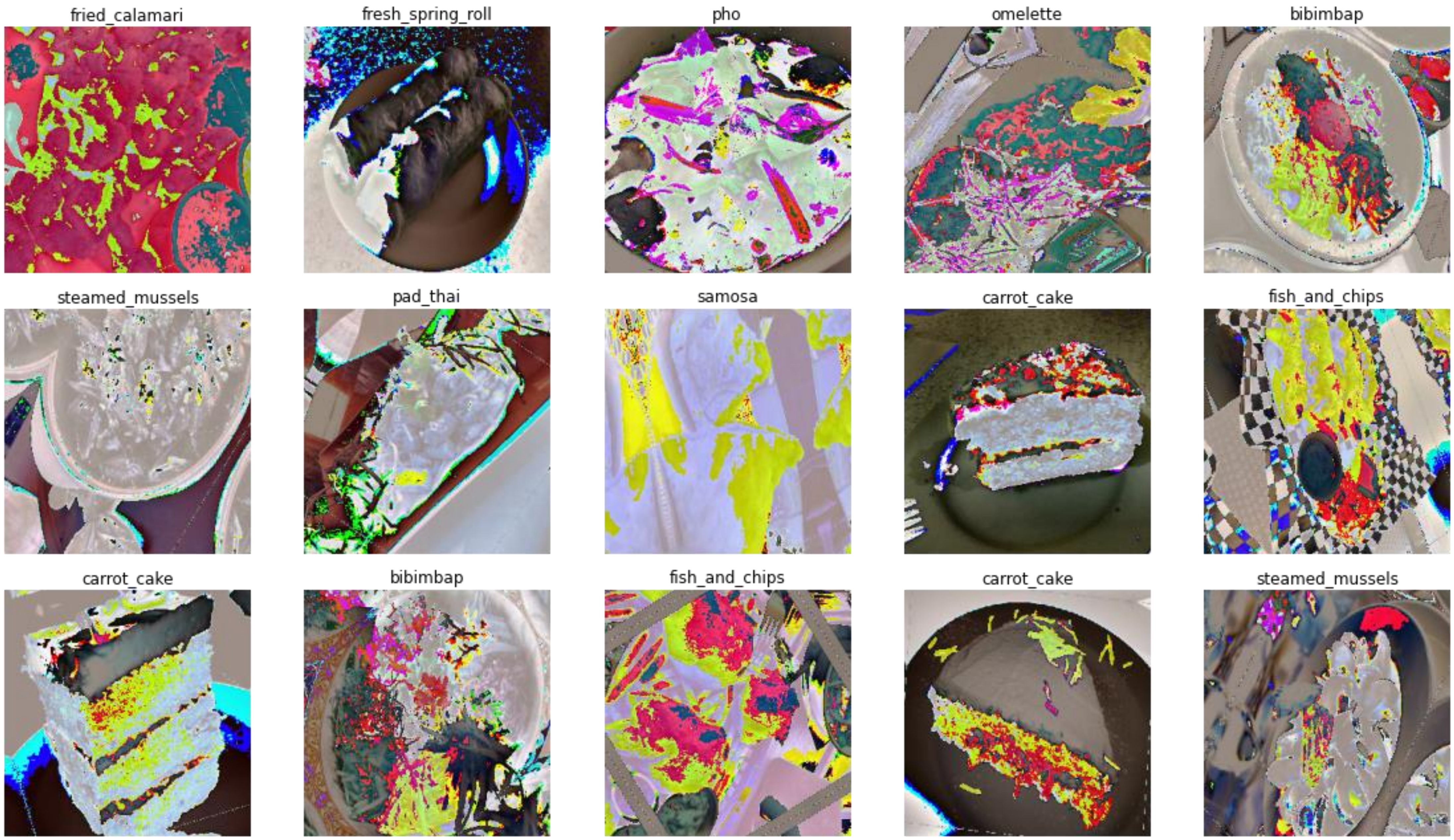
- **InceptionV3**: Normalize the pixel values between -1 and1
- **VGG16**: Each color channel is zero-centered with respect to the ImageNet dataset, without scaling.



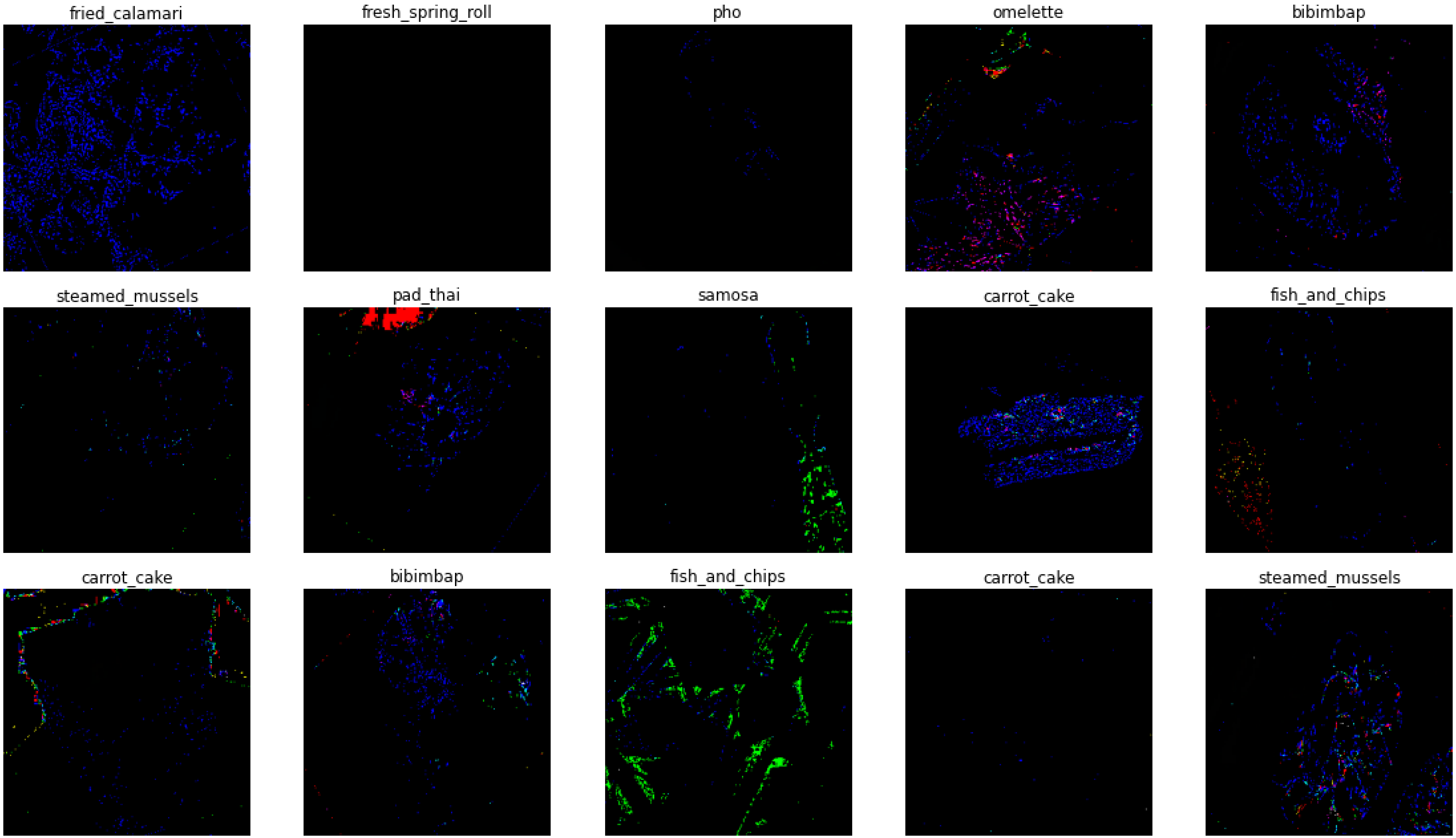
Original Images



VGG16 Preprocessed Images

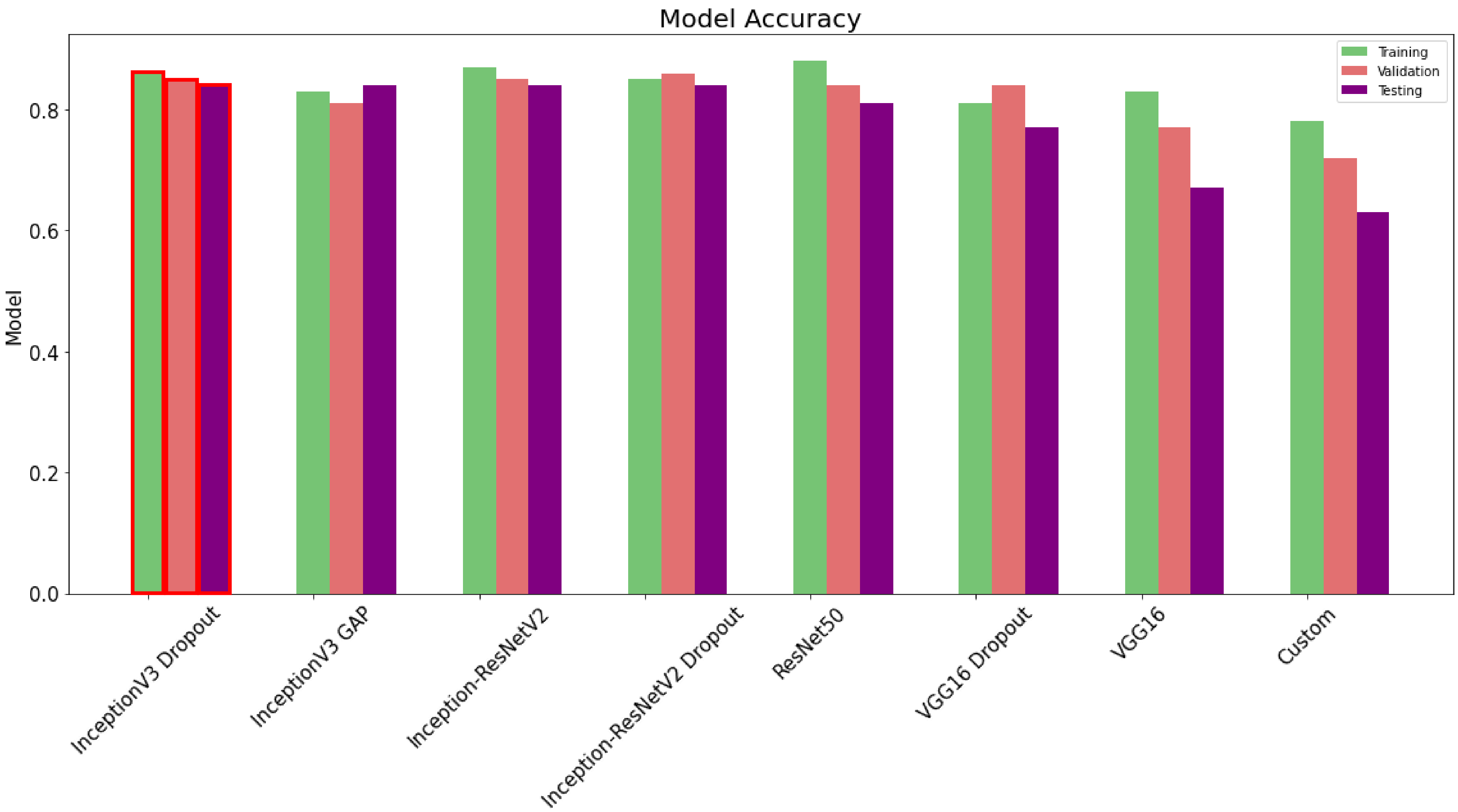


Inception V3 Preprocessed Images



Evaluation

Model Benchmark



All models performed better than the baseline accuracy of 3.4%

Best Performing Model
Inception V3 Dropout

Description:

Uses Transfer Learning on the architecture of Inception V3 CNN Model with weights from ImageNet dataset.

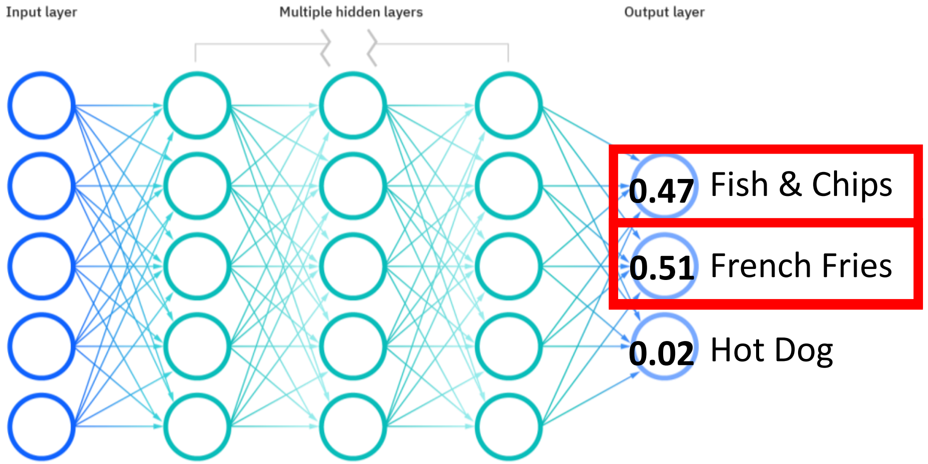
- Inception V3 image preprocessing (normalized between -1 and 1)
- Classification Layers:
  - 2 Dense layers (1024 and 29 filters)
  - Dropout layer (0.5)
- 49 layers and 2 million parameters to finetune.

Top-N Accuracy

Testing Set

Model	Top-1 Accuracy	Top-3 Accuracy	Top-5 Accuracy
Inception V3 Dropout	0.84	0.95	0.97

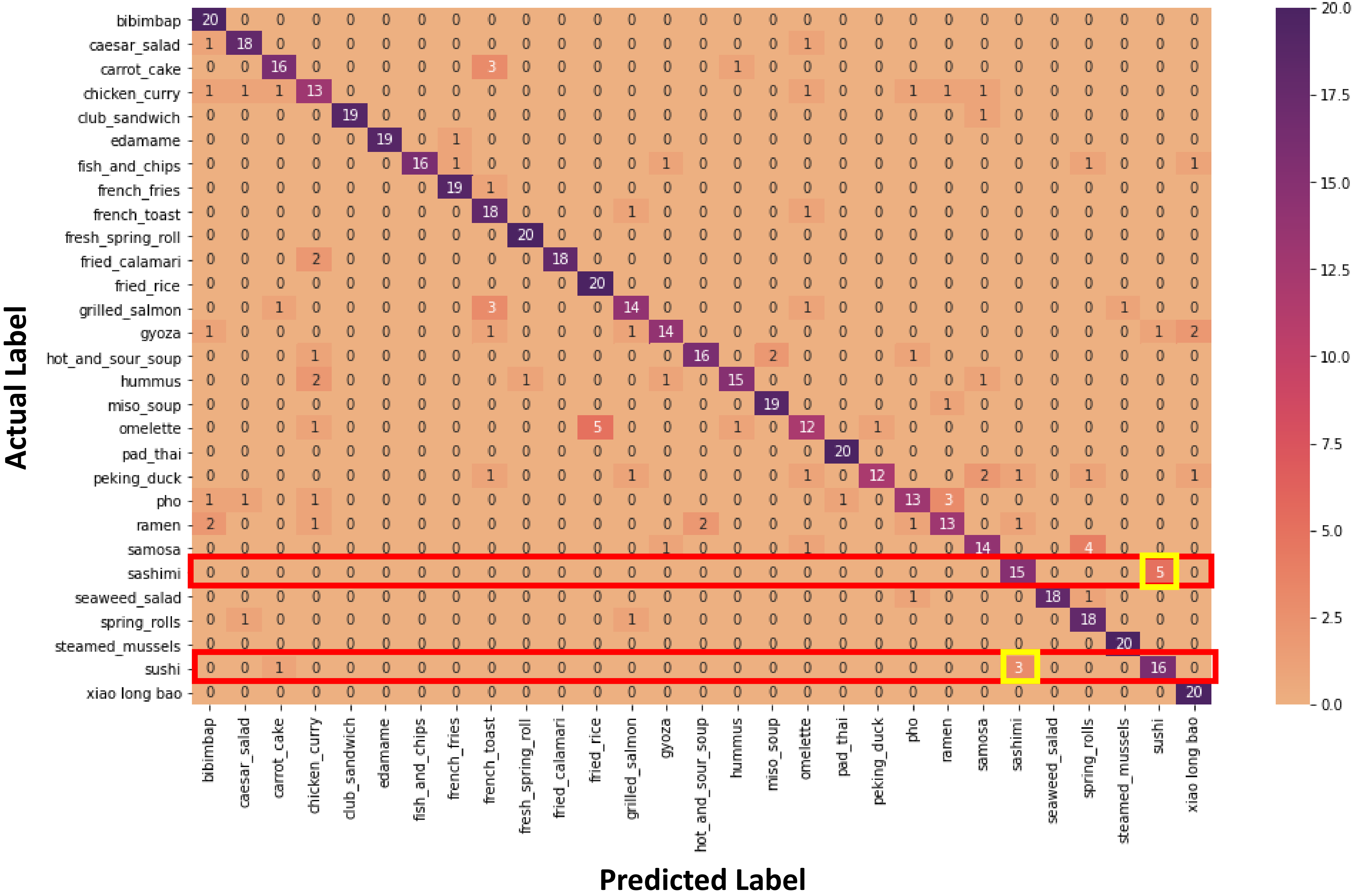
Fish & Chips



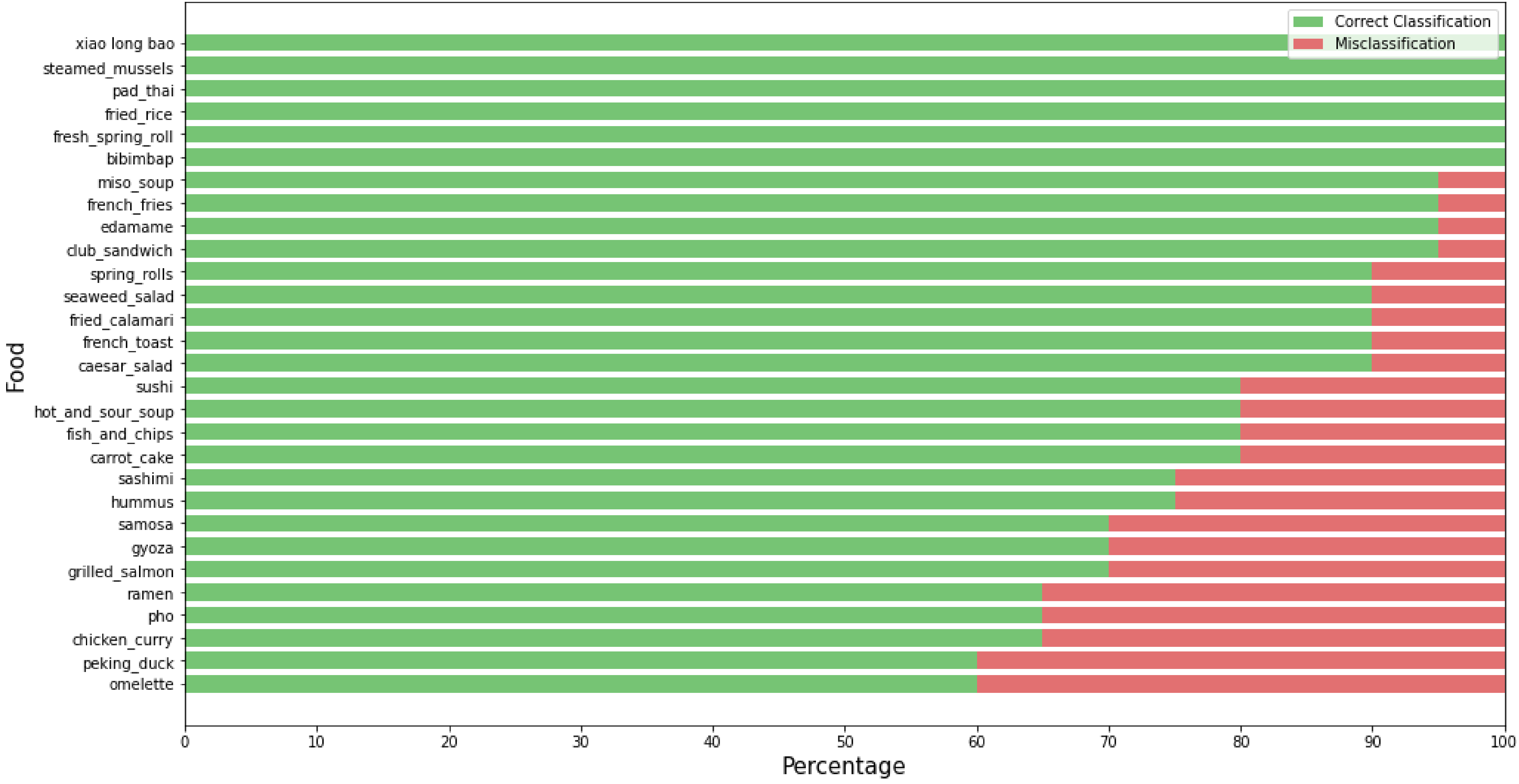
Top-1 Acc: ✗ Incorrect Prediction
Top-2 Acc: ✓ Correct Prediction

Web App Demo

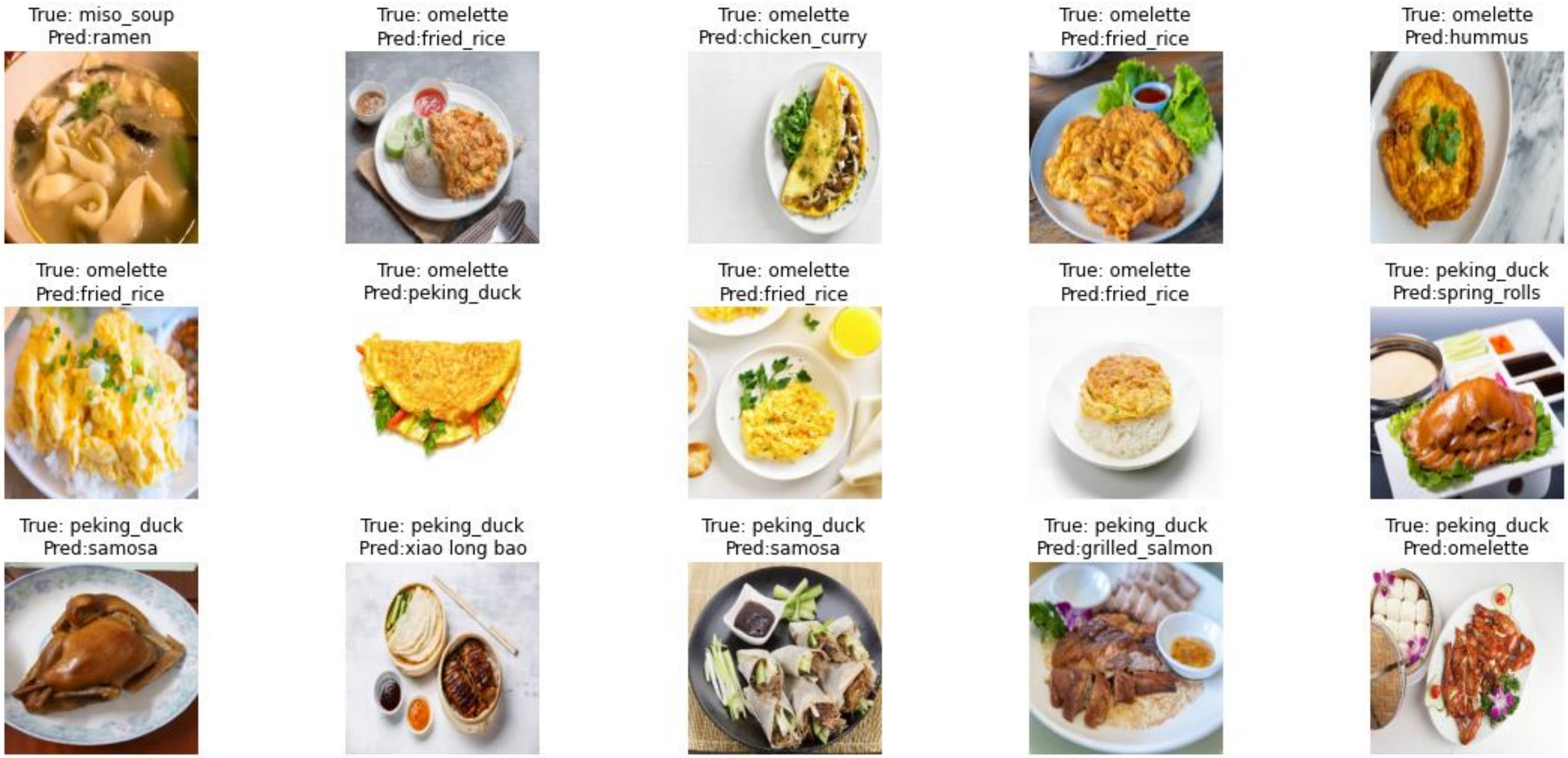
Confusion Matrix



Accuracy and Misclassification Rate by Food Class



Misclassified Food Examples



Limitations & Improvements

1

Multiple Food Types

Food Images can often contain multiple food classes
(eg. Fish&Chips vs French Fries)

Possible Solution
Assign class_weight when training to prioritise certain classes over others

2

Large intra-class diversity

Food Images belonging to same class might be diverse in how they look
(eg. Peking ducks – whole, sliced, duck rolls)

Possible Solution
Acquire more training data
and/or
Split classes that have large diversity

3

Large inter-class similarity

Food Images of different classes might look very similar
(eg. Sushi vs Sashimi)

Possible Solution
Acquire more training data
and/or
Group very similar classes together